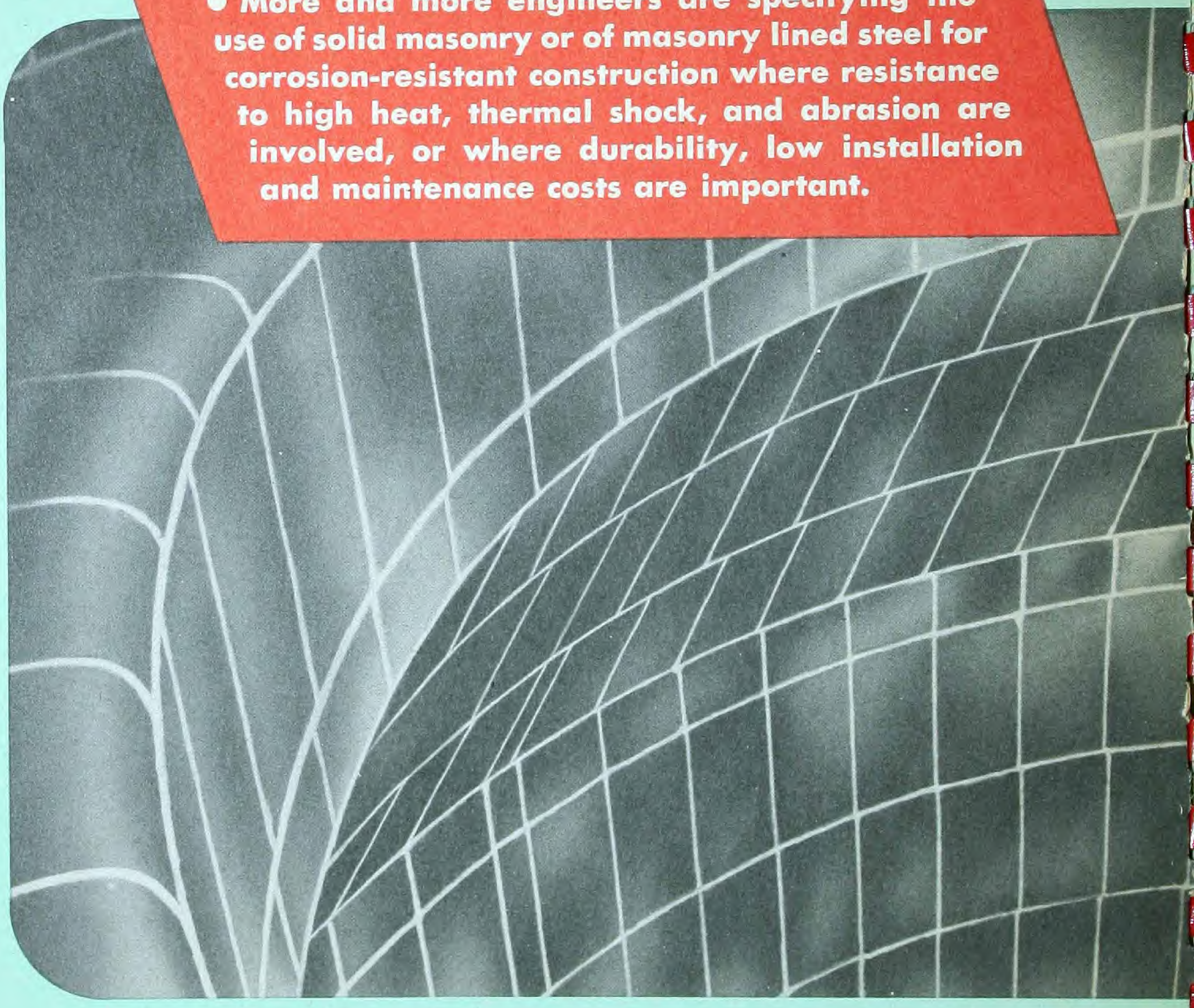
BULLETIN 810

CORROSION-RESISTANT MASONRY

Material and Construction Manual

● More and more engineers are specifying the use of solid masonry or of masonry lined steel for corrosion-resistant construction where resistance to high heat, thermal shock, and abrasion are involved, or where durability, low installation and maintenance costs are important.



Litho in U.S.A.

PROPERLY engineered and constructed, corrosion-resistant masonry will provide amazingly long trouble-free life. Failure, when it occurs, usually occurs at the joints, and almost always stems from improper selection of materials, or from improper design and construction—sometimes both.

This manual is divided into two sections. The first — MATERIALS — is designed to provide the engineer with sufficient information to enable him to select intelligently the most effective materials for a given type of construction and service. The second — CONSTRUCTION — contains a wealth of engineering data, design details, and construction aids that we have accumulated through our 80 years of leadership in the engineering and fabrication of corrosion-resistant materials and equipment.

THE U. S. STONEWARE COMPANY

Since 1865 • Akron 9, Ohio

Index

MATERIALS

Corrosion-Resistant Cements

THERE is far less possibility of going wrong in the selection of acid-proof brick and tile than in the selection of corrosion-resistant cements. Acid-proof brick and tile differ primarily in the nature of the clay used and in the production processes of the manufacturer. And while such differences unquestionably affect the life of corrosion-resistant masonry, most first quality acid-proof brick and tile are inert to the same corrosives at approximately the same temperature range.

Not so, however, with corrosion-resisting cements. There is no successful "all-purpose" bonding cement. U. S. Stoneware manufactures some eight different corrosion-resistant cements, each with certain individual characteristics designed to meet specific service requirements.

The Quick Selection Guide shown on the two following pages gives a sketch description of the principal characteristics of these eight cements. Detailed descriptions of each cement appear on following pages.

QUICK *Selection* GUIDE

DURISITE

Furane resin cement comes in form of a liquid and powder. For acids, alkalies, or solvents or for installations handling acids and alkalies alternately. Dense, non-porous. High compressive and tensile strength. Upper temperature limits 350°F to 375°F. Quick-setting. Cost Index 6*.

VITRIC-10

Silicate cement. Shipped in form of powder which must be mixed with 38° Be Silicate of Soda. Will handle all acids, except hydrofluoric, and all solvents. Not for use with alkalies. Relatively high porosity. Suitable for use at temperatures up to as high as 750°F. Quick-setting, chemical-hardening. Cost Index 2*.

PRE-MIXT

Silicate cement. Shipped in form of powder to be mixed with water. Characteristics similar to Vitric-10 though bonding strength to brick, and tensile strength is a fraction less than Vitric-10. More convenient to use and has somewhat better water resistance. Quick-setting, chemical-hardening. Cost Index 3*.

VITRIC FIREPROOF

Silicate cement for use in acid conditions continuously above 500° F. Cost Index 3*.

SUPER-VITRIC

Silicate cement for use where a dense, porcelain-like mortar is required. Supplied in the form of a special powder and special solution. Somewhat more difficult to handle than Vitric-10 or Pre-Mixt. Cost Index 4*.

VITRIC S-25

Silicate cement for use in strong acids only. Slower setting than Vitric-10 or Pre-Mixt. Cost Index 1*.

PORTITE

Sulphur-base heat-and-pour-type cement. Strong, extremely dense, resistant to most acids and mild alkalies. Not resistant to chromic or hydrofluoric acids, strong alkalies, or hydrocarbons. Suitable for temperatures up to approximately 200°F. Cost Index 2*.

SUPER-PORTITE

Characteristics similar to Portite, except that Super-Portite will handle hydrofluoric acid and has slightly greater flexibility. Cost Index 3*.

CARBO-PORTITE

A sulphur-carbon cement similar to Portite but resistant to hydrofluoric acid. Particularly useful in construction of hydrofluoric acid pickling tanks with carbon brick. Cost Index 3*.

*Relative cost of the cement only per brick is reflected in these cost index figures.

PROPERTIES CHART

	Durisite	Vitric 10	Pre-Mixt	Vitric Fireproof	Super-Vitric	Vitric S-25	Portite	Super-Portite	Carbo-Portite
Absorption.....	Less than 1/2 of 1%	14.29%	15%	14%	7%	14%	1/2 of 1%	1/2 of 1%	1/2 of 1%
Compressive Strength....	12,000 lbs.	3,500 lbs.	3,500 lbs.	3,600 lbs.	3,600 lbs.	3,600 lbs.	6,500 lbs.	6,500 lbs.	6,500 lbs.
Tensile Strength.....	1,400 lbs.	350 lbs.	340 lbs.	350 lbs.	400 lbs.	350 lbs.	700 lbs.	600 lbs.	600 lbs.
Modulus of Rupture.....	1,500 lbs.	450 lbs.	425 lbs.	448 lbs.	448 lbs.	448 lbs.	1,850 lbs.	2,000 lbs.	
Coefficient of Expansion.	14.4×10^{-6} 68°F to 350°F	6.4×10^{-6} 80°F to 500°F	6.4×10^{-6} 80°F to 500°F	6.4×10^{-6} 80°F to 500°F	6.4×10^{-6} 80°F to 500°F	6.4×10^{-6} 80°F to 500°F	8.3×10^{-6} 50°F to 200°F	8.3×10^{-6} 50°F to 200°F	8.3×10^{-6} 50°F to 200°F
Adhesion.....	450-500 lbs.	100 lbs.	80 lbs.	200 lbs.	200 lbs.	200 lbs.	425 lbs.	425 lbs.	425 lbs.
Setting Time.....	20-30 min.	20-30 min.	1 hour	25 min.	20 min.	25 min.	5 min.	5 min.	5 min.
Amt. required (per brick)	1/2 lb.	6/10 lb.	6/10 lb.	6/10 lb.	6/10 lb.	6/10 lb.	2 lbs.	2 lbs.	2 lbs.
Wt. of Mortar per cu. ft...	90-92 lbs.	120 lbs.	115 lbs.	120 lbs.	130 lbs.	120 lbs.	137 lbs.	140 lbs.	135 lbs.
Color.....	Black	White	White	Gray	White	White	Green-Gray	Black	Black
Shipping Units.....	50-125-250 500 lb. pkgs.	100 lb. bags	5-10-50-100-300 lb. pkgs.	100 lbs.	100 lb. bags	100 lb. bags	100 lb. bags	100 lb. bags	100 lb. bags
Upper Temperature Limits	360-375°F	750°F	750°F	2000°F	800°F	750°F	200°F	200°F	200°F

DURISITE
Alkali- and Acid-Resistant CEMENT

Durisite Alkali-and-Acid-Proof Cement represents possibly the biggest advance in corrosion-proof masonry construction in recent years. Durisite is one of the few bonding mortars which will handle both strong and weak acids and strong and weak alkalies, as well as all solvents. It will handle acids and alkalies alternately. And it will handle such solutions at temperatures up to as high as 350°-375°F.

Durisite is based on U. S. Stoneware's Duralon series of furane resins — synthetic resins characterized by extreme density, high compressive and tensile strength, and practically zero water absorption.

DURISITE CAN BE STORED INDEFINITELY

Durisite comes in the form of a powder and liquid for mixing on the job. Unlike synthetic cements of the phenolic type which deteriorate rapidly in storage and can be purchased safely only in quantities immediately needed, Durisite can be stored indefinitely before mixing, without deterioration. Thus adequate stocks can be kept on hand, available for immediate use for repairs or new construction.

Durisite liquid is 100% resin with no solvents added. Viscosity of the Durisite solution is thus absolutely uniform, assuring uniform mixing, uniform results.

DURISITE IS RESISTANT TO BOTH ALKALIES AND ACIDS

Durisite is inert to *all* acids, with the exception of high concentrations of highly oxidizing acids such as nitric and chromic. Laboratory tests indicate that Durisite will handle satisfactorily mild concentrations of nitric and chromic, but such applications should be approached with caution as they are definitely border-line cases. Durisite is inert to virtually *all* alkalies, *all* fats, oils and solvents. Durisite may be used with impunity where equipment is required to handle strong acids and alkalies, alternately. Durisite is likewise inert to fresh or salt water, or steam.

DURISITE IS DENSE, NON-POROUS

Durisite is extremely dense and impermeable. Absorption is less than ½ of 1%, approximately 1/25th of the best silicate type cements and substantially less than most other resinous cements. And, unlike resinous cements of the phenolic type whose porosity increases with age and temperature, Durisite's dense, non-porous structure is permanent, remaining virtually the same, and completely impermeable, even at elevated temperatures.

DURISITE IS QUICK-SETTING

Durisite sets quickly, by internal chemical reaction, taking an initial set in 20-30 minutes. Setting time can be easily controlled to suit the requirements of the individual job; however, normal setting time permits continuous laying of brick without danger of lower courses being squeezed out by weight of upper courses. Durisite is tough, durable, easy to use. It is highly resistant to abrasion, to impact shock, and to rapid changes in temperature.

DURISITE IS NON-TOXIC

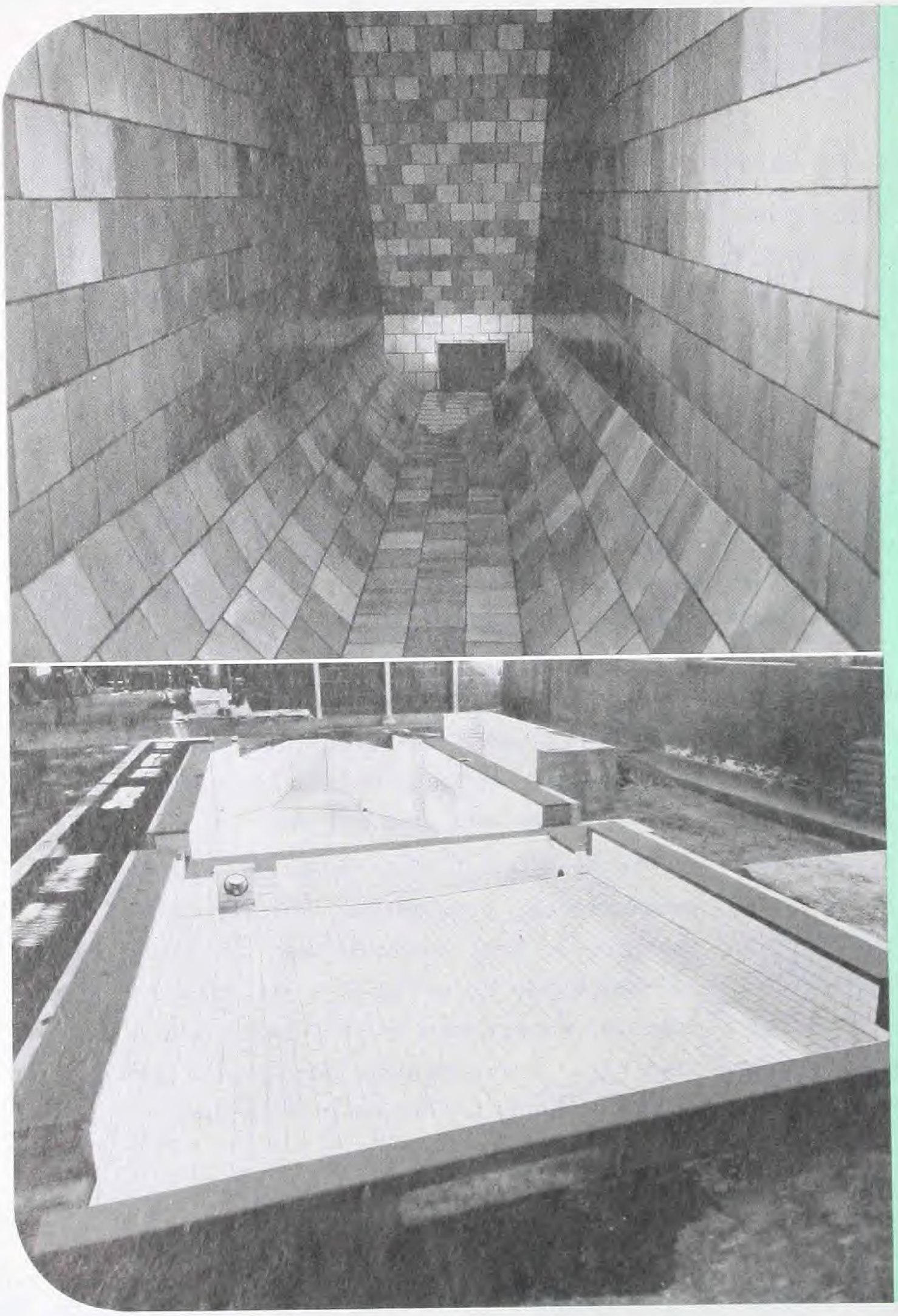
Durisite is non-toxic, has no dangerous effect on the skin. No explosive or inflammable hazard. Only normal precautions are required in handling — Durisite should be mixed in a well ventilated room as the vapors may be annoying to some workmen; cement should be removed from the hands before it sets as removal after hardening is difficult. A yellow stain may occur when the materials are handled with the bare hands. This stain while not dangerous may be difficult to remove. It is suggested that whenever possible gloves be worn and the hands be frequently washed with soap and water.

The vapors from Durisite mortar are non-toxic, non-flammable, non-explosive, but may prove annoying to some workmen. For this reason Durisite should be handled in a well ventilated area, and arrangements should be made to conduct vapors downward away from the bricklayer while the lining installation is being made.

DURISITE

Alkali- and Acid-Resistant

CEMENT



PHYSICAL PROPERTIES *and* TECHNICAL DATA ON DURISITE

Absorption: Less than ½ of 1% ASTM tests.

Compressive Strength: 12,000 lbs. sq. in.

Tensile Strength: Over 1,400 lbs. sq. in.

Modulus of Rupture: 1,500 lbs. sq. in. (fully cured).

Coefficient of Expansion: Mean Linear Co-efficient of Thermal Expansion, per degree F: 14.4×10^{-6} at a temperature range of 68°F to 350°F.

Adhesion: Excellent to acid brick, tile, and other non-metallic materials. Approximately 4-5 times that of silicate type cements.

Setting Time: Durisite takes an initial set within 20-30 minutes at room temperature. May be placed in service 2 to 3 days after the last brick is laid. (Maximum chemical resistance, however, is not obtained until mortar is fully cured. Curing time varies with temperature.)

Joint Thickness: $\frac{1}{16}$" to ⅛".

Weight: 1 cubic foot of mortar weighs 90-92 lbs.

Amount Required: Approximately ½ lb. of mortar per 9" brick, buttered 3 sides.

Color: Black.

Shipping Units: 50 lbs., 125 lbs., 250 lbs., 500 lbs.

CHEMICAL RESISTANCE OF DURISITE CEMENT

The following table showing resistance characteristics of Durisite is based on laboratory and field experience over approximately a three-year period. It is offered as a guide only and should not be considered as an expressed or implied guarantee. In the case of solutions marked "requires special consideration" it is suggested that full details be sent to U. S. Stoneware's Process Equipment Division for their consideration and súggestions.

1 Quite satisfactory.

Acetic acid, all concentrations including glacial
Acetic anhydride
Acetaldehyde
Acetone
Aluminum chloride solutions
Aluminum sulphate solutions
Ammonium hydroxide, all concentrations
Ammonium carbonate solutions
Ammonium chloride solutions
Ammonium fluoride solutions
Ammonium phosphate solutions
Ammonium sulphate solutions
Aniline
Barium hydroxide solutions
Benzene
Benzine
Benzoyl chloride
Bleach solutions: most but not all
Boric acid solutions
Calcium hydroxide solutions
Carbon bisulphide
Carbon tetrachloride
Chloride of lime
Chloroform
Citric acid solutions
Cocoanut oil
Copper sulphate
Ethyl acetate
Ethyl alcohol
Ethyl ether
Ferric chloride solutions
Ferric sulphate solutions
Formaldehyde
Formic acid
Gasoline
Glycerine
Hydrochloric acid, all concentrations
Hydrofluoric acid, all concentrations
Hydrogen sulphide solutions
Iodine in potassium iodide solution
Lactic acid, all concentrations
Magnesium chloride solutions
Maleic acid
Methyl alcohol
Nickel chloride solutions
Nickel sulphate solutions
Oleic acid
Oxalic acid solutions
Petroleum ether
Phenol solutions
Phosphoric acid, all concentrations
Potassium hydroxide, all concentrations
Sodium hydroxide, all concentrations
Sodium carbonate solutions
Sodium sulphide solutions
Stearic acid solutions
Sulphuric acid up to 1.5 sp. gr.
Sulphurous acid, all concentrations
Sulphur monochloride
Trichlorethylene
Toluene
Xylene
Zinc chloride solutions

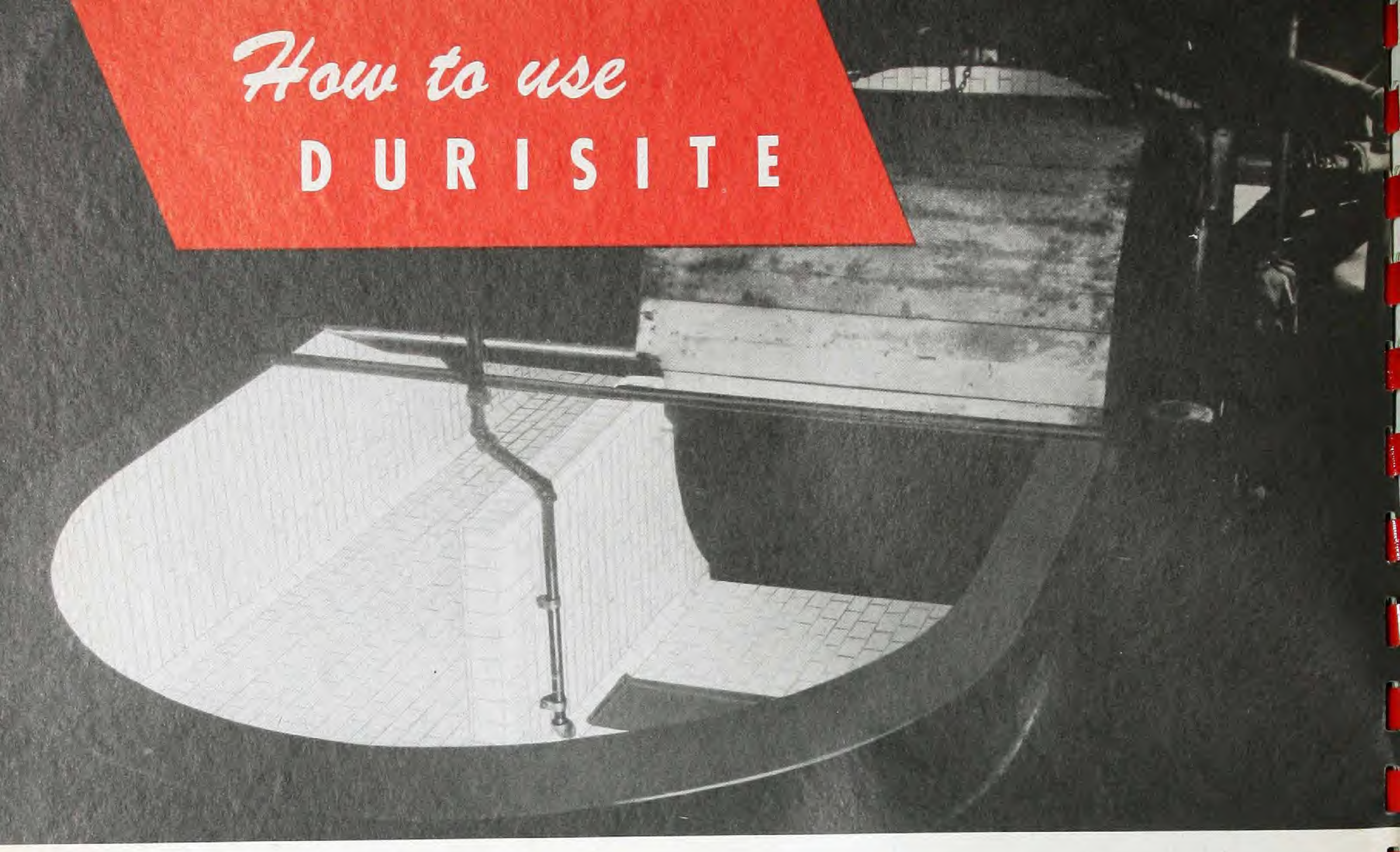
2 Generally require special consideration or actual test under specific conditions, but usually satisfactory.

Bleach solutions
Bromine water
Chlorine water
Sodium hypochlorite solutions
Peroxide solutions
Ammonium bromide
Ammonium nitrate

3 Generally unsatisfactory.

Nitric acid
Chromic acid
Pure bromine
Aqua Regia
Sodium chlorite in acid solutions

How to use DURISITE



MIXING PROCEDURE

We recommend that batches be mixed in amounts of 5 lbs. of mortar per man; that is, 3 lbs. of Durisite Powder to 2 lbs. of Durisite Liquid.

1 Weigh out the proper amount of Durisite Liquid (2 lbs. for each bricklayer) and pour into mixing pan. Where one bricklayer is working alone it is more economical to mix directly in the mortar pan in individual batches.

2 Weigh out the proper amount of Durisite Powder (3 lbs. for each bricklayer). Slowly add about half of the Durisite Powder to the Liquid in the mixing pan, stirring constantly until smooth mortar is obtained. Add remaining half of Powder, mixing until smooth and free from air bubbles or lumps. The Powder should be pressed into the Liquid. Mixing should be so thorough that there remains no unwetted Powder and no free Liquid.

Note: The consistency of the mix may be varied within a limited range by the use of more or less Powder. The ideal consistency can be determined by handling the mortar with a small trowel. The mortar should not run freely from the trowel but should flow off slowly in strings.

It is important to remember that thicker mortars set up more quickly, thinner mortars less quickly than the standard working times shown in the table on Working Time.

3 Scrape out all the Durisite Mortar from the mixing pan to the mortar pan, thus leaving the mixing pan ready for mixing another batch as needed.

WORKING TIME

The working time depends upon the temperature. Working time refers to the time that the Durisite mortar remains in workable condition. The mortar should be discarded as soon as it begins to set. It cannot be reworked and used again, and should not be retempered with additional Liquid.

The table of working time that follows is offered as a guide only.

Temperature	60°F	70°F	80°F	90°F
Working Time	1 hour	30 minutes	15 minutes	10 minutes

If it is desirable to lengthen working time of Durisite mortar to accommodate mixing larger batches, the Durisite Liquid can be chilled prior to mixing by immersing the closed Liquid container in cold or ice water.

APPLICATION OF MORTAR

1. Brick must be dry, and preferably at room temperature.
2. The acid-proof brick used should be dense, with clean, square-cut edges.
3. Brick should be buttered on three sides.
4. Joint thickness should range between 1/16" and 1/8".

THINGS TO CONSIDER IN THE CONSTRUCTION OF CORROSION-PROOF MASONRY WITH DURISITE

While it is common practice in most acid-proof masonry construction using silicate type cements to incorporate an impervious membrane between a steel shell and the brick lining, such a membrane is not always required when using Durisite. See section headed "Impervious Membranes for Corrosion-Resistant Masonry Linings," page 35. However, it is recommended that in brick lining a concrete or steel tank, a prime coat of U. S. Stoneware's Tygon Paint, or other suitable paint be applied prior to laying the brick. For steel in high temperature service, beyond the range of primers, it is primarily a problem of design. U. S. Stoneware engineers will be glad to lend their assistance in suggesting proper procedure on specific problems.

It is a wise precaution to be sure that all voids in back of the brick are filled with Durisite Cement. In cases of extreme unevenness of the tank walls a leveling coat of Durisite Cement may be applied directly over the prime coat to eliminate the possibility of voids.

POINTING OF OLD BRICK WITH DURISITE

Rake out all old joints square to better than a ½" depth — be sure to remove all loose particles. If a thorough wash doesn't effect a chemically neutral condition the cleaned surface should be neutralized and rewashed. In pointing be sure that joints are packed full to force out air bubbles and fill all voids.

NOTE: To secure a smooth surface on the joint dip trowel in Durisite liquid before stroking.

PUTTING DURISITE CONSTRUCTION INTO SERVICE

Under average conditions Durisite bonded corrosion-proof masonry can be placed in service within 2 to 3 days. If the corrosive agent be entirely acid (not intermittent acid and alkali) the construction can be put into service within one day. If the corrosive agent is intermittently acid and alkali, or entirely alkali or solvent, a minimum of three days' setting is recommended. For such service it is preferable that the installation be heated to an average temperature of 100°F to 110°F for 12 to 24 hours to assure complete chemical hardening. Heating can be done by hot air, heat lamps, steam radiator coil, or other unit heater. It is also possible to use open steam provided the material has taken an initial set, say after one day, and provided that no pressure is built up in the vessel. For weak alkali or dilute alkaline solutions heating is not necessary and the installation can be placed in service within three days.

FOR CASTING PURPOSES

For casting small corrosion-resistant parts we recommend the use of Duralon casting resin, the basic resin from which Durisite Cement is made. For further information write our engineering department.

VITRIC-10

Quick-Setting Chemical-Hardening ACID-PROOF CEMENT

Vitric-10 is a quick-setting, chemical-hardening, sodium silicate cement. It comes in the form of a powder and is mixed at the time of use with 38° Be. sodium silicate solution.

Like Durisite, Vitric-10 takes an initial set within 20-30 minutes, permitting continuous laying of brick without danger of the lower courses being squeezed out by the weight of the upper courses. The self-hardening and quick-setting action will take place even in a vacuum, for the reaction is purely a chemical one. Vitric-10 sets uniformly all the way through and behind the joints.

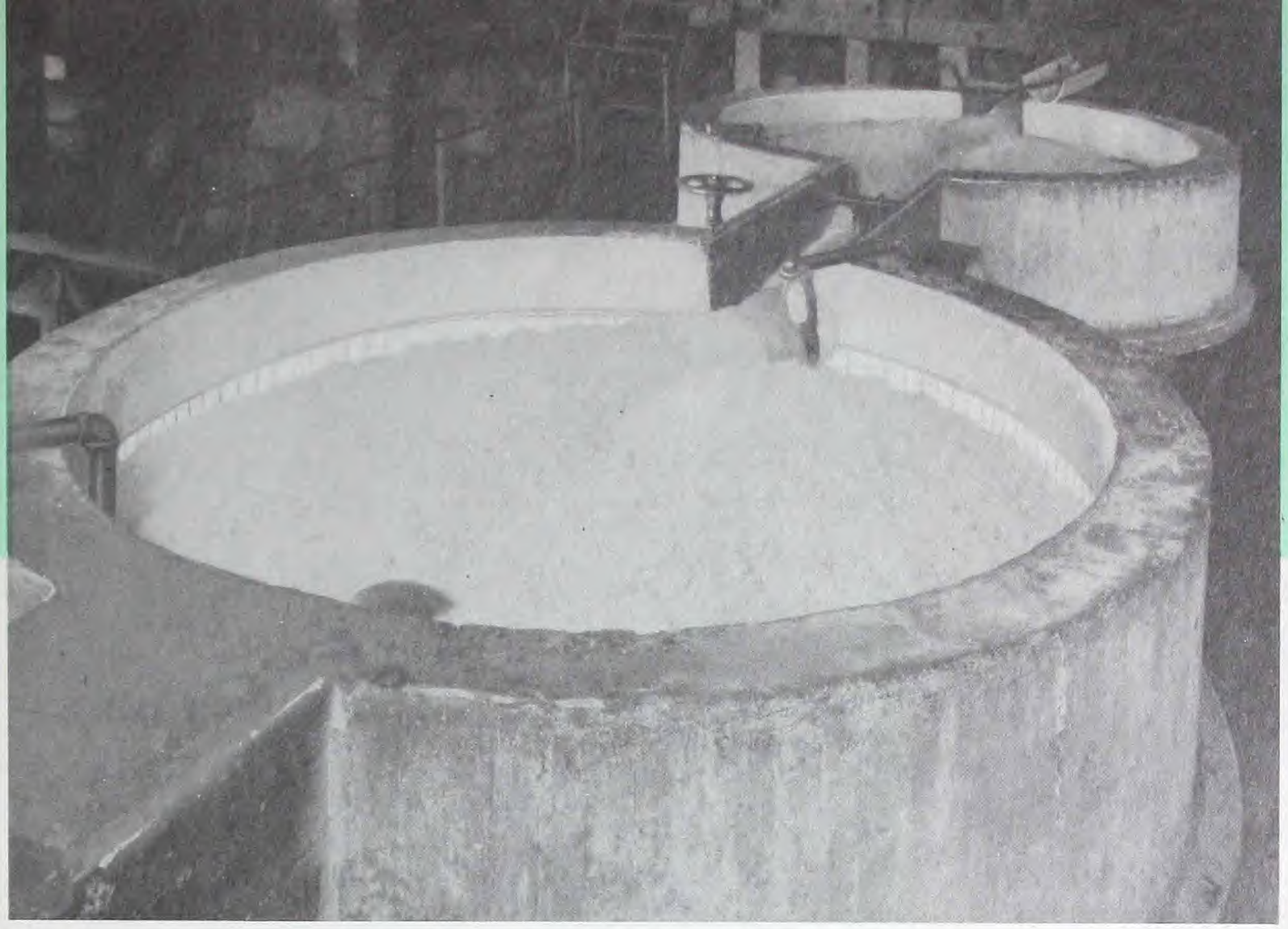
Vitric-10 is inert to all acids, organic or inorganic, except hydrofluoric; to solutions of acid and neutral salts, except fluorides; to chlorine, bromine, and iodine; and to organic solvents, alcohols, and oils. See table on pages 16-17.

Vitric-10 can be subjected to temperatures as high as 1600°F, though some strength is lost at temperatures above 750° F. For continuous use above 500°F we recommend the use of Vitric Fireproof cement, described on page 20.

Vitric-10 is not suitable for use with alkalies, or solutions of alkali salts; hydrofluoric acid or fluorides; or acetone oil.

Vitric-10 powder may be stored indefinitely without deterioration if kept away from moisture.

Vitric-10 has no dangerous effect on the skin. No explosive or inflammable hazards, no annoying fumes. In using Vitric-10 for acid-proof masonry construction in the food industries the hardened acid-proof cement should be treated with a 10% solution of calcium chloride and then be washed with water.



10' ID x 20' high Acid-Proof Brick-Lined Tanks In Continuous Bleaching System

IMPERVIOUS MEMBRANES WITH VITRIC-10

Vitric-10, like all sodium silicate cements, is neither flexible nor free from porosity. In using Vitric-10 as the bonding mortar in acid-proof masonry linings it is highly recommended that an impervious membrane be used between the brick and the shell. Concrete, wood and brick tanks definitely require such a membrane.

If the tank leaks, the cement work will also leak. If the walls of the tank move, the brick lining will crack. The tendency for a wall to move may be caused by strains due to temperature changes, chemical action, alternate wetting and drying, as well as by strains due to hydrostatic head or foundation settling. It is not wise to line a rectangular wooden tank with brick unless one is certain the wood will not be distorted by strains from any of the above sources. All tanks should be tested with water to be sure of freedom from leakage before a brick lining is installed.

Probably the most suitable tank for supporting a brick lining is of steel. A steel tank which is liquid tight does not always need a membrane between the brick sheathing and the steel. Even though the solution might seep through the brick and cement (due to their natural porosity) a protective coating is formed (under some conditions, though not in all) on the steel; and unless the solution is allowed to circulate between the steel and the brick sheathing (due to leakage of the steel tank or cracks in the brick sheathing), this coating remains and prevents further corrosion. The use of an inner lining or membrane, however, is definite assurance against the dangers of hidden corrosion. See section headed "The Use of Impervious Membranes with Corrosion-Resistant Masonry Linings," page 35.

PHYSICAL PROPERTIES AND TECHNICAL DATA ON VITRIC-10

Absorption: ASTM tests 14.29%

Compressive Strength: 3500 lbs. sq. in.

Tensile Strength: 350 lbs. sq. in.

Modulus of Rupture: 450 lbs. sq. in.

Coefficient of Expansion: Mean Linear Coefficient of Thermal Expansion per degree F—6.4x10-6 at a temperature range of 80°F to 500°F.

Adhesion: 500 lbs.

Setting Time: Vitric-10 takes an initial set within 20-30 minutes at room temperature. May be placed in service within 2-3 days after the last brick is laid.

Joint Thickness: 1/16" to 1/8".

Weight: 1 cubic foot of mortar weighs approximately 120 lbs.

Amount Required: Approximately 6/10 lb. of mortar per 9" brick, buttered 3 sides.

Color: White.

Shipping Units: 100 lb. waterproof bag.

THE FOLLOWING

Acetaldehyde	Resistant
Acetaldehyde & Mercuric Chloride 1:1	Resistant
Acetic Acid & Compounds	Resistant
Acetic Anhydride	Resistant
Acetoacetic Acid	Resistant
Acetoacetic Ester	Resistant
Acetone	Resistant
Acetone Oil	*Attacked*
Acetyl-Bromide	Resistant
Acetyl Chloride	Resistant
Acetylene Dichloride	Resistant
Acetyl Salicylic Acid (Aspirin)	Resistant
Alizarin Sulfonic Acid	Resistant
Aluminum Bromide	Resistant
Aluminum Chloride	Resistant
Aluminum Fluoride	*Attacked in acid solutions*
Aluminum Sulfate and Alums (watch crystallization cracking)	Resistant
Amidosulfonic Acid	Resistant
Ammonia	Resistant
Ammonium Bromide	Resistant
Ammonium Carbonate—50% Solution	Resistant
Ammonium Chloride	Resistant
Ammonium Diphosphate—20% Solution	Resistant
Ammonium Fluoride	*Attacked*
Ammonium Nitrate	Resistant
Ammonium Nitrate—Concentrated Solution	
To a Solution of: 50% Ammonium Tungstate	
20% Concentrated Ammonia	
10% Water	Resistant
Ammonium Sulfate & Persulfate	Resistant
Ammonium Persulfate—50% Solution	
To a Solution of: 50% Ammonium Persulfate	
20% Sulfuric Acid	
30% Water	Resistant
Ammonium Persulfate—50% Solution mixed with 20% Sulfuric Acid	Resistant
Ammonium Phosphates	Resistant
Ammonium Sulfide, Concentrated Solution	Resistant
Amyl Alcohol	Resistant
Amyl Acetate	Resistant
Aniline	Resistant
Aniline Hydrochloric Acid	Resistant
Aniline Hydrochloric, Molten	Resistant
Antimonic Acids	Resistant
Antimony Chloride	Resistant
Antimony Oxychloride	Resistant
Antimonyl Potassium Tartrate (Tartar Emetic)	Resistant
Aqua Regia	Resistant
Arsenic Compounds — Antimony Compounds Neutral or Acid	Resistant
Barium Chloride Solution	Resistant
Barium Hydroxide	*Attacked*
Benzenesulfonic Acid	Resistant
Benzaldehyde—Neutral or Acid	Resistant
Benzine (Petroleum)	Resistant
Benzoic Acid	Resistant
Benzene (Benzol)	Resistant
Benzene-Methyl Alcohol Mixtures in All Proportions	Resistant
Benzene Sulfonic Acid	Resistant
Benzene Sulfonic Chloride	Resistant
Benzyl Acetate	Resistant
Benzyl Chloride	Resistant
Bleaching Powder, Concentrated Solution—Sodium	*Attacked*
Calcium	Resistant
Boric Acid	Resistant
Bromine	Resistant
Bromine Water, Saturated	Resistant
Butanol	Resistant
Butoxyl (Methylbutyleneglycol Acetate)	Resistant
Butyl Acetate	Resistant
Butyric Acid	Resistant
Calcium Chloride	Resistant
Calcium Hydroxide	*Attacked*
Calcium Nitrate	Resistant
Calcium Sulfate—Concentrated Solution	Resistant
Carbon Bisulfide	Resistant
Carbon Oxychloride (Phosgene) (except at high temperatures)	Resistant
Carbon Dioxide	Resistant
Carbon Tetrachloride	Resistant
Caustic Potash—50% Solution	*Attacked*
Caustic Soda—50% Solution	*Attacked*
Chloracetic Acid (watch crystallization in previous layer)	Resistant
Chloral	Resistant
Chlorbenzene	Resistant
Chloride of Lime — Concentrated Solution	Resistant
Chlorine Dioxide, Aqueous Solution	Resistant
Chlorine, Free	Resistant
Chlorine Water, Saturated	Resistant
Chloric Acid	Resistant
Chloronaphthalene	Resistant
Chloroform	Resistant
Chlorosulfonic Acid (2-3 months) Cold	Resistant
Chlorosulfonic Acid (2-3 months) Hot	Resistant
Chromic Acid — 50% Solution — Hot	Resistant
Chromic Acid — 50% Solution — Cold	Resistant
Chrome Chloride	Resistant
Chromium Potassium Sulfate—Conc. Solution	Resistant
Citric Acid	Resistant
Copper Acetate, 50% Solution	Resistant
Copper Chlorides	Resistant
Copper Nitrate	Resistant
Copper Sulfate (watch crystallization)	Resistant
Cresol, Boiling	Resistant
Essential Oils	Resistant
Ether	Resistant
Ethyl Acetate	Resistant
To a Solution of:	
9.0% Ethyl Acetate	
0.5% Acetic Acid	
0.5% Sulfuric Acid	
90.0% Water	Resistant
To the vapor of the above mixture	Resistant
Ethyl Alcohol—96%	Resistant
Ethyl Alcohol	Resistant
Ethylamine	Resistant
Ethyl Bromide	Resistant
Ethyl Chloride	Resistant
Ethylene Chloride	Resistant
Ethylene Disulfonic Acid	Resistant
Ethylene Oxide	Resistant
Ethyl Ether	Resistant
Ethyl Sulfate	Resistant
Ethyl Sulfuric Acid	Resistant

TABLE SHOWING

resistance characteristics of Vitric-10 is derived from field experience over a period of many years. We believe it to be thoroughly reliable.

Ferric Chloride Solution—80% ..... Resistant
Ferric Sulfate Solution ..... Resistant
Ferri- and Ferro-cyanide Salts ..... Resistant
Fluosilicic Acid ..... Resistant
Formaldehyde ..... Resistant
Formic Acid & Compounds ..... Resistant

Gallic Acid Solution ..... Resistant
Glacial—Acetic Acid ..... Resistant
(watch crystallization)
Glycol Monoacetate ..... Resistant

Hydrazine Sulfate ..... Resistant
Hydriodic Acid ..... Resistant
Hydrobromic Acid ..... Resistant
Hydrochloric Acid ..... Resistant
Hydrochloric Acid
To a Solution of: Hydrochloric Acid with 10% hydrogen peroxide ..... Resistant
Hydrocyanic Acid ..... Resistant
Hydrofluoric Acid ..... *Attacked*
Hydrofluoric Acid 40% ..... *Attacked*
To a Solution of: 3 parts hydrofluoric acid .....
6 parts nitric acid — 65%
90 parts hydrochloric acid —36% ..... *Attacked*
Hydrofluoric Acid 75%— 50% by weight .....
Sulfuric Acid 95%— 50% by weight ..... *Attacked*
Hydrofluoric Acid 75%— 25% by weight .....
Sulfuric Acid 95%— 50% by weight .....
Water—25% by weight ..... *Attacked*
Hydrogen Sulfide ..... Resistant
Hypochlorous Acid ..... Resistant

Iodine ..... Resistant
Iodoform ..... Resistant
Iron Chloride ..... Resistant
(watch crystallization cracking)
Iron Sulfate ..... Resistant

Lactic Acid & Compounds ..... Resistant
Lead Chloride ..... Resistant
Lead Nitrate ..... Resistant

Magnesium Chloride ..... Resistant
(watch crystallization)
Magnesium Sulfate ..... Resistant
Maleic Acid & Compounds ..... Resistant
Malic Acid ..... Resistant
Manganese Chloride ..... Resistant
Manganese Sulfate ..... Resistant
Manganese Oxides ..... Resistant
Mercuric Chloride and Acetaldehyde 1:1 ..... Resistant
Mercuric Chloride Solution ..... Resistant
Mercury Chlorides ..... Resistant
Methanol (Methyl Alcohol) ..... Resistant
Methyl Acetate ..... Resistant
To a Solution of:
0.5% Acetic Acid .....
0.5% Sulfuric Acid .....
9.0% Ethyl Acetate .....
90.0% Water ..... Resistant
Methanol (Methyl Alcohol) and Benzene in any proportion ..... Resistant
Methylbutyleneglycol Acetate (Butoxyl) ..... Resistant
Methyl Cyclohexanol ..... Resistant
Methylene Chloride ..... Resistant
Methylsulfate ..... Resistant
Methyl Sulfonic Acid ..... Resistant
Milk of Lime ..... Resistant
Molybdenum Acids ..... Resistant
Molybdenum Oxides ..... Resistant

Naphthalene (Sulfonated) to 100° C ..... Resistant
100°-180° C. ..... Resistant
Naphthalenesulfonic Acid ..... Resistant
Naphtholsulfonic Acid ..... Resistant
Nickel Chloride ..... Resistant
(watch crystallization)
Nickel Sulfate ..... Resistant
Nitrates ..... Resistant
Nitrogen Acids ..... Resistant
Nitrobenzene ..... Resistant
Nitrogen Oxides ..... Resistant
Nitroglycerine ..... Resistant
Nitrophenol/Water 1:1 ..... Resistant
Nitrotoluene ..... Resistant

Oils — Vegetables, Minerals and Greases (All Kinds) ..... Resistant
Oleic Acids and All Compounds (Esters) ..... Resistant
Oxalic Acid and Compounds ..... Resistant
Oxides—Chlorides: Vanadium .....
Tungsten .....
Bismuth ..... Resistant

Paradimethylaminobenzophenone ..... Resistant
Paraffin wax, molten ..... Resistant
Perchloric Acid ..... Resistant
Phenol Sulfoacids ..... Resistant
Phenol, molten, boiling ..... Resistant
Phenol, 20% solution ..... Resistant
Phosgene (Carbon Oxychloride) ..... Resistant
(Except at high temperatures)
Phosphoric Acid—up to 70% ..... Resistant
Phosphorous Acids ..... Resistant
Phosphorous Bromides ..... Resistant
Phosphorous Chloride ..... Resistant
Phosphorous Oxychloride ..... Resistant
Phthalic Acid ..... Resistant
Potash Chrome Alum, Concentrated Solution ..... Resistant
Potassium Bicarbonate — 50% solution ..... Resistant
Potassium Bichromate, Concentrated Solution ..... Resistant
Potassium Bichromate, mixed with 30% Sulfuric Acid ..... Resistant
Potassium Bromide 50% Solution ..... Resistant
Potassium Carbonate Solution ..... *Attacked*
Potassium Chlorate, Concentrated Solution ..... Resistant
Potassium Compounds ..... Resistant
(except alkaline compounds and fluorine compounds)
Potassium Cyanide Concentrated Solution ..... *Attacked*
Potassium Cyanide 20% ..... *Attacked*
Potassium Ferri - Cyanide, Conc. Solution ..... Resistant
Potassium Ferro - Cyanide, Conc. Solution ..... Resistant
Potassium Hydroxide, 50% Solution ..... *Attacked*
Potassium Nitrate, Conc. Solution ..... Resistant
Potassium Oxalate, Conc. Solution ..... Resistant
Potassium Permanganate, 50% Solution ..... Resistant
Potassium Peroxide, 20% Solution ..... *Attacked*
Potassium Persulphate, 50% Solution ..... Resistant
Potassium Sulphate, 50% Solution ..... Resistant
Potassium Sulphide, 50% Solution ..... *Attacked*
Prussiate of Potash, Red ..... Resistant
Prussiate of Potash, Yellow ..... Resistant
Pyridine ..... Resistant

Salicylicacid ..... Resistant
Selenium Compounds—Sulfur Compounds (for acid or neutral solutions) ..... Resistant
Silicon Tetrachloride ..... Resistant
Soda Solution ..... *Attacked*
Sodium Acetate Solution ..... Resistant
Sodium Bichromate Solution ..... Resistant
Sodium Bichromate Saturated Solution with 2% Chromic Acid ..... Resistant
Sodium Bichromate Concentrated Solution with 30% Sulfuric Acid ..... Resistant
Sodium Bisulphate, Concentrated Solution ..... Resistant
Sodium Bisulphite, 30% Solution ..... Resistant
Sodium Carbonate Solution ..... *Attacked*
To a Solution of Sodium Carbonate—20 parts ..... Tungstate—50 parts ..... Water—30 parts ..... *Attacked*
Sodium Chloride Solution ..... Resistant
Sodium Chromate Solution ..... Resistant
Sodium Chlorosulphonate 50% Solution ..... Resistant
Sodium Chromate Concentrated Solution ..... Resistant
Sodium Hydroxide Solution up to 50% ..... *Attacked*
Sodium Hypochlorite Solution ..... *Attacked*
Sodium Oxalate Concentrated Solution ..... Resistant
Sodium Peroxide Solution up to 20% ..... *Attacked*
Sodium Sulphide 20% Solution up to 25° C. ..... *Attacked*
Sodium Sulphite Solution ..... Resistant
Sodium Tartarate Solution ..... Resistant
Sodium Thiosulphate Solution ..... Resistant
Sulfuric Acids ..... Resistant
Sulfuric Acid—98% ..... Resistant
To a Solution of:
Sulfuric Acid 0.5% .....
Acetic Acid 0.5% .....
Ethyl Acetate 9.0% .....
Water 90.0% ..... Resistant
To a Solution of:
Sulfuric Acid 20% .....
Ammonium Persulfate 50% .....
Water 30% ..... Resistant
To a Solution of: 30% Sulfuric acid with the addition of conc. potassium bichromate ..... Resistant
Sulfur Chloride ..... Resistant
Sulfur Molten ..... Resistant
Stearic Acid ..... Resistant
Sulfurous Acid ..... Resistant
Sulfur Oxides ..... Resistant
Sulfur Oxychloride ..... Resistant
Sulfuryl Chloride (Sulfur Oxychloride) ..... Resistant

Tartaric Acid & Compounds — Winestone ..... Resistant
Tetrachloroethane ..... Resistant
Tin Chlorides ..... Resistant
Tin Hydroxides (Neutral or Acid Solutions) ..... Resistant
Tin Sulfates ..... Resistant
Titanium Chloride ..... Resistant
Titanium Sulfate ..... Resistant
Titanium Hydroxide ..... Resistant
Toluene (Toluol) ..... Resistant
Toluenesulfonic Acid ..... Resistant
Trichloracetic Acid ..... Resistant
Trichlorethylene ..... Resistant

Urea ..... Resistant
Uric Acid ..... Resistant

Xylene (Xylol) ..... Resistant

Zinc Chloride ..... Resistant
Zinc Sulfate ..... Resistant

How to use VITRIC-10 CEMENT

1 "Vitric-10" Acid-Proof cement must be mixed with a sodium silicate solution of the following analysis:

Chemical Ratio: One part Na_2O to 3.20-3.25 parts SiO_2

Specific Gravity: 1.355 or 38 deg. Be.

Du Pont (Grasselli Chemical Div.) Brand No. 29 or Philadelphia Quartz Company's Brand No. N-380 are of this exact analysis. As an alternate, Du Pont (Grasselli) "F" Brand or Philadelphia Quartz Brand "N" will work satisfactorily. *It is of extreme importance that the proper grade of sodium silicate be used.* Concentrated solutions of proper ratio sodium silicate can be reduced to 38 deg. Be. by adding water in the following proportion:

If the solution is	Add pounds of water	To pounds of solution	To make pounds Silicate 38 deg. Be.
42.5° Be.	12.5	87.5	100
41.5° Be.	8.0	92.0	100
41.0° Be.	7.5	92.5	100
40.0° Be.	6.0	94.0	100

2 Weigh out 3 pounds of Sodium Silicate Solution of 38 deg. Be. into a container that is clean and dry and make a mark at the liquid level so that future measurements may be made by volume. Then, weigh out 8 pounds of "Vitric-10" Powder into another container and again mark the level so future measurements can be made by volume.

Empty the 3 pounds of Sodium Silicate Solution into a mixing box. To this add about 9/10ths of the 8 pounds of Cement Powder (always add the Powder to the Solution, *never* add the Solution to the Powder) and mix until all of the Powder has gone into a paste and until all the air bubbles have escaped from the mortar. Then add more Powder and mix thoroughly until a mortar of the required consistency is obtained and all air bubbles have been worked out. This usually requires the remainder of the 8 pounds of Powder, but it is important to have a mortar thin enough to be handled in buttering bricks.

It is important that the cement be mixed to a consistency which can readily be handled by a bricklayer, and if necessary the ratio of sodium silicate to "Vitric-10" Powder may be somewhat altered in order to make a good workable mix under the conditions prevailing at the time of use.

AN IMPORTANT NOTE ON TEMPERATURE

The working time of the cement is influenced by the temperature. At temperatures ranging from 70 deg. F. to 85 deg. F. the 11 pounds of mortar may be easily used by the bricklayer before it has had time to set up. In cold weather it is possible to make larger batches without danger of the cement setting up before use. In hot weather it is sometimes advisable to mix smaller batches. However, the working time may be lengthened by cooling the mortar box, which is easily done by setting the outside of the mortar box in cold water. In unusually cold weather (less than 50 deg. F.) it is advisable to keep the ingredients of the mortar, and the brick, warm. "Vitric-10" must not be exposed to freezing temperatures during mixing or setting.

	TEMPERATURE				
	40°F.	50°F.	60°F.	70°F.	80°F.
WORKING TIME (before partial setting)	5 hr.	1.5 hr.	30 min.	20 min.	15 min.
HARDENING TIME (ready to use)	7 days	5 days	4 days	3 days	2 days

THE FOLLOWING POINTS ARE IMPORTANT

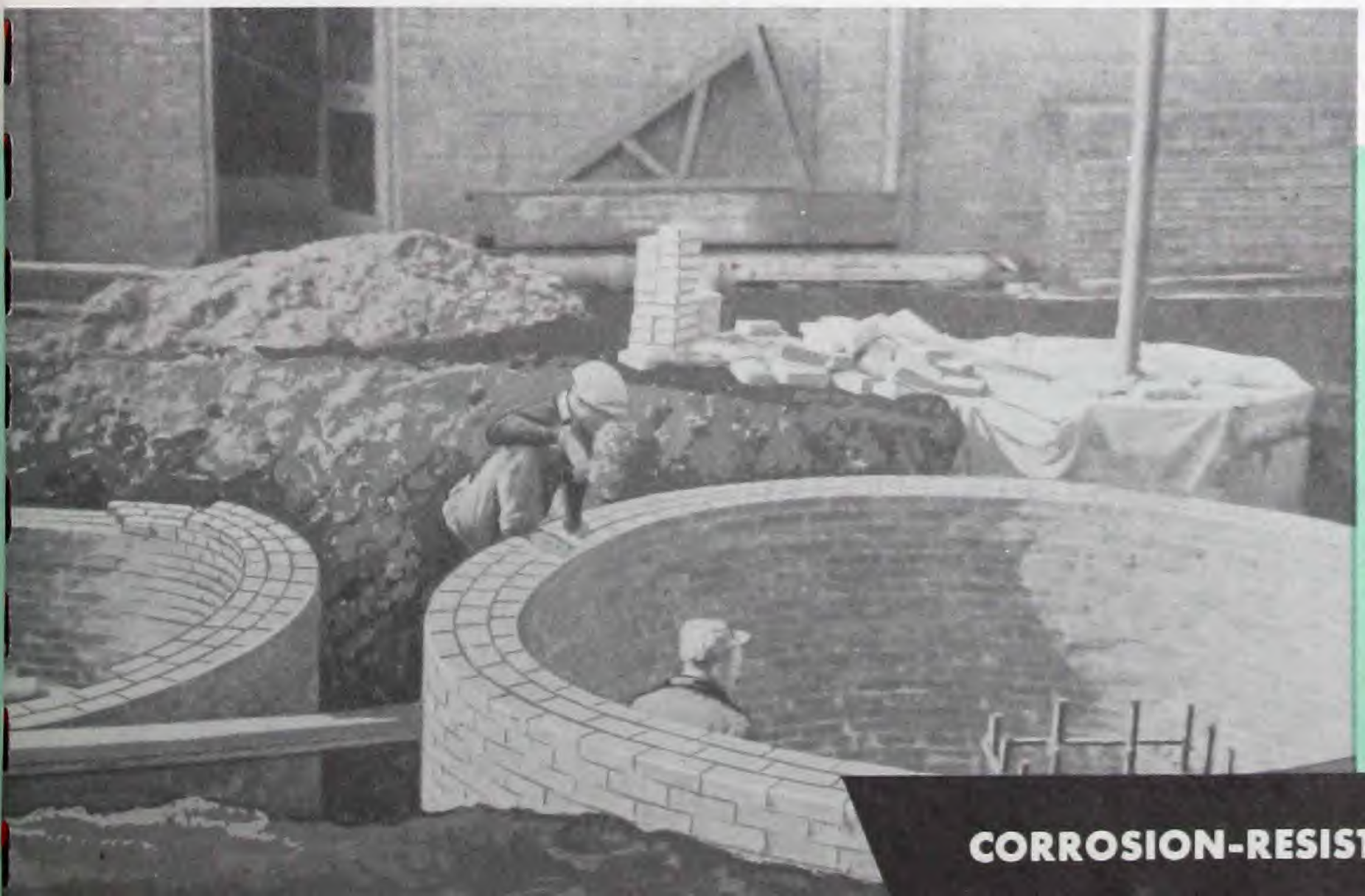
3 **a.** At 70° F. "VITRIC-10" takes an initial set within 20 to 25 minutes after mixing and the masonry work is ready for use within 2 to 3 days at this temperature without artificial heating or drying. Only a quantity of mortar that will be used within 15 minutes should be mixed at a time. Unused mortar which has begun to take a partial set should be removed from the Mixing Box and Mortar Boxes and discarded before fresh batches are put into them. It is not permissible to add new Silicate to such partially set mortar, because this does not renew the plasticity of the mix.

b. The Powder should always be added to the Solution, NEVER THE REVERSE. The mixing must be thorough and complete. All lumps must be broken up until there are no traces left of the dry Powder or excess Silicate. No water must be allowed to come in contact with the dry Powder.

c. The cement joints should be pressed out thin, to not more than ⅛". The aim should be to secure a SOLID cement joint, which is accomplished by pressing down on each joint when laying the brick. "VITRIC-10" is self-hardening and chemical-setting throughout the joints and behind the bricks. There is practically no shrinkage on setting.

d. Acid-soaked surfaces should be neutralized with dilute caustic, and alkaline surfaces with dilute HCL, then water washed, and dried thoroughly before applying the "VITRIC-10" Acid-Proof brick lining. As a rule, it is advisable to install an impervious membrane before lining with acid brick. "VITRIC-10" must never be applied directly to concrete.

e. "VITRIC-10" does not require any acid or heat treatment in order to make it set up completely. It is advisable, however, to neutralize the slightly alkaline surface of the hardened joints by washing them with a 5% to 10% solution of hydrochloric acid. This neutralization is especially recommended where the first liquid to be in contact with the cement joints is water, very dilute or very strong acid. The salts formed by the neutralization should be removed by washing with water after the acid has soaked in the cement. When the acid-proof masonry is to be used in the food industry where the purity of the product is important, the hardened cement joints should first be treated with a 10% solution of calcium chloride and then washed with water.



Acid-Proof Masonry Construction can be ready for use within 24 to 36 hours.

SPECIAL *Silicate* CEMENTS

SUPER-VITRIC

Silicate cements are by nature somewhat porous and while for most applications the amount of porosity present is not excessive, there are certain occasions where the use of silicate cements is indicated but where their natural porosity may be too high for the proposed use. For such applications Super-Vitric was developed — a silicate cement with less than half the porosity of the normal silicate types. Super-Vitric consists of a special powder and special solution which we furnish on order. Instructions furnished must be followed exactly. Chemical resistance of Super-Vitric is equal to Vitric-10.

VITRIC FIREPROOF

Vitric-10 cement begins to lose strength above 750°F, and becomes vitrified at 1800°. For applications where temperature conditions are continuously above 500°F we recommend the use of Vitric Fireproof, a silicate cement designed expressly for high heat service. Physical properties and method of handling are similar to Vitric-10.

PRE-MIXT

Pre-Mixt is a silicate cement shipped in the form of a powder to be mixed with water at the time of use. Practically equal to Vitric-10 in efficiency, Pre-Mixt eliminates the necessity of adding silicate of soda. Pre-Mixt, however, is extremely susceptible to moisture and must be kept absolutely dry in storage. Tensile and adhesive strengths of Pre-Mixt are slightly under that of Vitric-10.

VITRIC S-25

A slower-setting silicate cement designed for use in strong acids only. Somewhat less expensive than the quicker-setting types. Vitric S-25 increases materially in strength in strong acid service.

OTHER USES FOR SUPER-VITRIC CEMENT

Super-Vitric silicate cement is effectively used for assembling and cementing electrical parts, lamp bases, instruments, resistors, heating elements, radio parts, fuse and spark plugs, etc.

PORTITE
Sulphur Cements

STANDARD PORTITE

Portite is a sulphur base heat-and-pour type cement suitable for use with many acids and mild alkalies at temperatures up to a maximum of 200°F. Portite is extremely dense, non-porous and impermeable.

CHEMICAL RESISTANCE

Portite is inert to the attack of such acids as sulphuric, hydrochloric, acetic, lactic, phosphoric in any concentration; to nitric acid up to 30%. It is unaffected by sodium chloride, ammonium chloride, ferric chloride, ammonium nitrate, copper sulphate, ferro sulphate, sodium chlorate, sodium phosphate, potassium chromate, zinc chloride, etc. It is resistant to mild concentrations of alkalies. Portite, however, should not be used with strong alkalies, chromic acid, hydrofluoric acid, or with hydrocarbons.

TOXICITY

Portite is non-toxic, has no dangerous effect on the skin. No explosive hazard. Fumes from the molten Portite are likewise non-toxic though they may prove slightly annoying to some workmen.

POROSITY

Portite is non-porous and non-absorbent, in this respect comparing favorably with Durisite.

HOW TO USE PORTITE

Portite is shipped in the form of chips. The chips are heated in an iron kettle and poured into the joints between the bricks at a temperature of approximately 280°F. Portite solidifies within five minutes — is ready for use within an hour after the last joint is poured. Joint thickness should be approximately ¼".

CARBO-PORTITE

A sulphur-carbon cement compound, alike in physical characteristics to Portite; but, unlike regular Portite, Carbo-Portite is resistant to hydrofluoric acid, as well as to the chemicals to which Portite is resistant. Carbo-Portite is particularly useful in connection with the construction of hydrofluoric acid pickling tanks with carbon brick.

SUPER-PORTITE

A sulphur-carbon cement compound having the same characteristics as Portite and Carbo-Portite, but particularly suitable where thermal and mechanical shocks exist. Super-Portite will not crack or lose tensile or compressive strength under frequent temperature changes.

OTHER USES FOR PORTITE CEMENT

For grouting foundations, anchoring steel to concrete, cementing bolts to concrete, porcelain, or stoneware, and for casting purposes.

THE USE OF IMPERVIOUS MEMBRANES WITH PORTITE

With the Portite series of cements, as with almost all corrosion-resistant bonding mortars, the use of a membrane between the shell and brick lining, while not always absolutely necessary, is suggested. For a more complete discussion of their use, refer to the section headed "The Use of Impervious Membranes with Corrosion-Resistant Linings."

Properties

OF THE PORTITE SERIES OF ACID-PROOF CEMENTS

	Portite	Carbo-Portite	Super-Portite
Absorption	½ of 1%	½ of 1%	½ of 1%
Compressive Strength	6000 lbs.	6000 lbs.	6500 lbs.
Tensile Strength	600 lbs.	600 lbs.	700 lbs.
Modulus of Rupture	1850 lbs.	1850 lbs.	2000 lbs.
Coefficient of Thermal Expansion	$8.3x10^{-6}$	$8.3x10^{-6}$	$8.3x10^{-6}$
Adhesion	500 lbs.	500 lbs.	500 lbs.
Setting Time	5 minutes	5 minutes	5 minutes
Amount Required (per brick)	2 lbs.	2 lbs.	2 lbs.
Weight per cu. ft.	140	137	140
Color	Black	Black	Gray-black
Shipping Units	50-lb. carton	50-lb. carton	50-lb. carton

PUTTY AND CAULKING COMPOUNDS

PLASTITE CHEMICAL PUTTY

Plastite is a waterproof and corrosion-resistant cement compound which can be troweled or extruded through a caulking gun. It never completely loses its plasticity and can usually be easily removed after a period of service. Plastite finds extensive use as a caulking compound for tower pipe bells, as a packing material for expansion joints, for repairing external cracks in corrosion-proof masonry, and as a general sealing putty around manholes, etc. It is likewise used as a glazing compound for windows in chemical and metallurgical plants where ordinary putty is quickly hardened and attacked by corrosive fumes. Standard containers hold 50 lbs.

NEOSEAL

An uncured, highly tacky rubber sheet material which readily adheres to itself. Neoseal is used as a crack filler and general repair material where an adhesive, non-curing, putty-like rubber mass is indicated. Corrosion-resistance of Neoseal approaches that of rubber though it is inferior to compounded and cured rubber sheets.

CALKTITE

Calktite is a smooth-pouring, asphaltic-base caulking compound, resistant to both acids and alkalies. Originally developed for use in sewer construction where a tight, corrosion-resistant joint is required, Calktite is now widely used as a membranous coating in the construction of acid tanks and floors, and as a protective coating over masonry to resist corrosive gases or spillage. Calktite does not set too hard, thus allowing flexibility, expansion and contraction. Calktite has a melting point (ball and ring method) of 206-215°F. A special grade of Calktite, known as Calktite HM is available with a melting point of 247-255°F. Recommended pouring temperature for both types is 350-400°F. Standard containers hold 35 lbs., 70 lbs., 175 lbs., and 400 lbs.

Characteristics of Calktite

	Calktite	Calktite HM
Penetration 100 g. 5 sec. @ 77	8-12	6-7
Penetration 100 g. 5 sec. @ 122	35-40	19-24
Melting Point, Ball and Ring	206-215°F	247-255°F
Recommended Pouring Temperature	350-400°F	350-400°F

"USSCO" *Acid-Proof Brick*

Almost any first quality acid-proof brick will show satisfactory chemical resistance immersed in a laboratory acid solution. The true test of an acid-brick, however, is how well they stand up in service. And true serviceability depends not so much on their ability to resist acid attack, which in most cases can be taken for granted, but on certain highly important physical properties which some brick possess, but which many brick lack.

Factors to look for in an acid brick:

1. Structural Strength.
2. Resistance to Thermal and Mechanical Spalling.
3. Resistance to Salt Crystallization.
4. Resistance to Erosion.
5. Accuracy in Shape, and
6. Surface.

These physical properties are a direct result both of the clays used and the manufacturing process.

U. S. Stoneware owns and operates its own clay mines located in what geologists recognize as the heart of an area rich in clays unexcelled for corrosion-resisting purposes.

For more than 80 years U. S. Stoneware has been a manufacturer of clay products for the chemical industry.

These two facts are, in themselves, assurance of an acid brick about as fine as money can buy. And when you stop to think that the cost of transportation, handling, and laying are about the same for all brick, the slight additional cost for "USSCO" Acid-Brick is of small importance.

"USSCO" Acid-Brick are structurally strong, extremely dense, hard, highly resistant to spalling and erosion. Molded under high pressure, de-aired to eliminate air pockets, the resultant brick have a minimum of open pores in which salt crystallization can occur. The care taken in

manufacture assures uniform and accurate shaping, so essential to uniform joints.

"USSCO" Acid-Brick are resistant to all acids, organic and inorganic, except hydrofluoric, all alkalies, and all solvents.

It might be well to note here that where operating temperatures are under 300°F Acid-Proof Brick should not exceed 4% in porosity. Brick of greater porosity will generally prove unsatisfactory for the vast majority of applications under 300°F due to their greater tendency to spall from crystallization.

Brick having a porosity ranging between 1% and 4% permit better bonds with corrosion-resistant cements and also offer better elasticity to corrosion-resistant masonry permitting them to absorb greater thermal shock and mechanical strain.

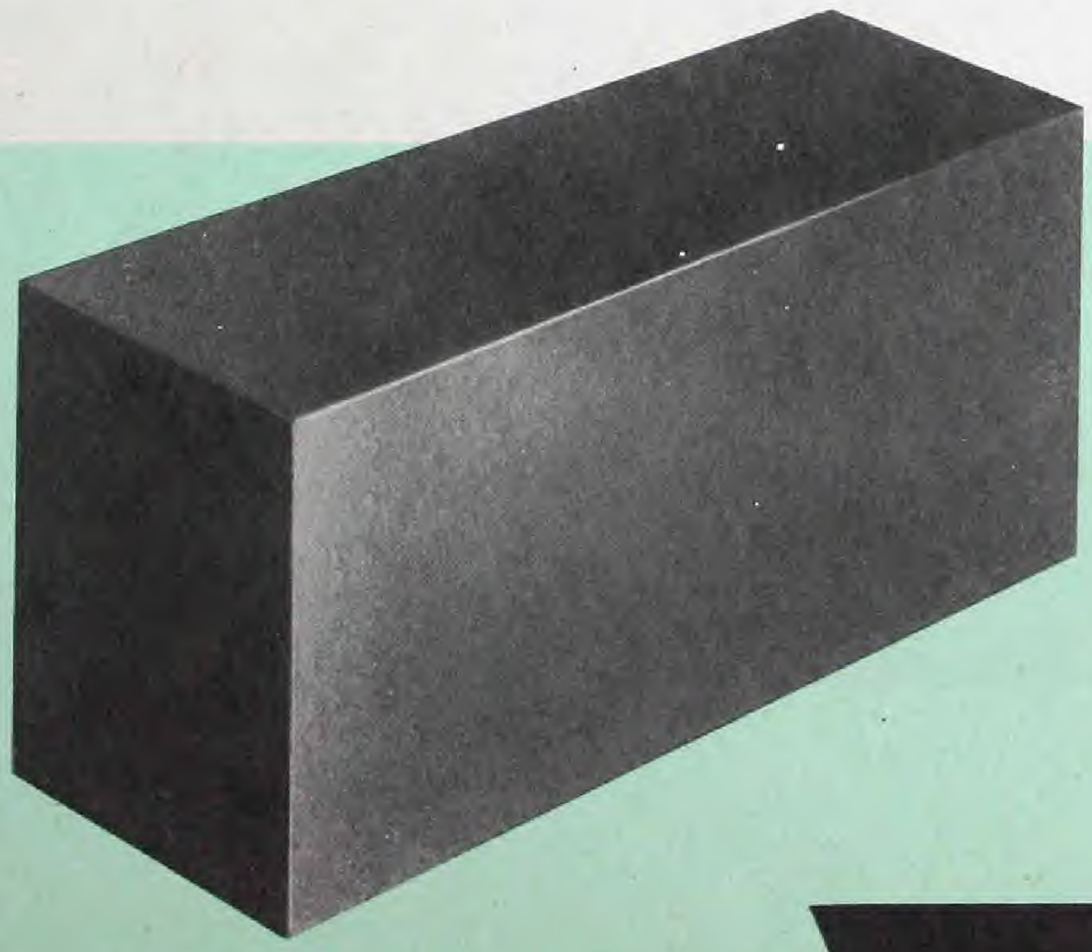
Brick of even lower porosity (less than 1%) are also available and these are often to be recommended where resistance to thermal shock and mechanical strain are not of prime importance.

Such brick, however, with their low porosity and high crushing strength, usually contain high percentages of fluxing materials which in general lower their corrosion-resistance, unless they are produced from relatively more expensive materials such as chemical stoneware, Ceratherm, or chemical porcelain, thus necessitating a much higher selling price than for standard acid-proof brick.

These low porosity brick made from the more expensive materials are in demand for use in acid-proof flooring, walls, and for lining vessels handling weak acids, such as foods, pharmaceuticals and fine chemicals, where minimum absorption of contaminating substances, and ease of cleaning are of paramount service.

Brick for high temperature service such as stacks, hot fume ducts, roasting ovens, etc., may be somewhat more porous, and still give satisfactory service, due to the fact that such construction is seldom in contact with liquids which would cause crystal formation. Under these services, however, it is highly important that the brick be made from high grade materials which inherently have a low percentage of extractable impurities as the total area exposed to attack (including pore space) is greatly increased.

Standard sizes of "USSCO" Brick, usually available from stock, are illustrated on the following pages. Special brick can be made to order in any size or shape on order. Delivery can usually be made in six to eight weeks. Standard shapes should be specified whenever possible as their use usually means more economical installation.



CARBON BRICK

Carbon brick are available in the standard 9" series of sizes and shapes for use in corrosion-resistant masonry handling hydrofluoric acid or fluorides. Carbon brick are not generally used where ceramic brick would be suitable as they are considerably more expensive. Carbon brick weigh substantially less than ceramic brick and have higher thermal conductivity.

8"x3¾"x2¼" SERIES

8" STRAIGHT SERIES
8"x3¾"x2¼"

No. 1 WEDGE
8"x3¾"x(2¼"-1¾")

No. 2 WEDGE
8"x3¾"x(2¼"-1⅜")

No. 1 ARCH
8"x3¾"x(2¼"-2")

No. 2 ARCH
8"x3¾"x(2¼"-1½")

No. 3 ARCH
8"x3¾"x(2¼"-1")

8" SPLIT BRICK
8"x3¾"x1⅛"

NECK BRICK
8"x3¾"x(2¼"-⅝")

No. 1 KEY
8"x(3¾"x3⅜")x2¼"

No. 2 KEY
8"x(3¾"-3")x2¼"

No. 3 KEY
8"x(3¾"x2⅝")x2¼"

No. 4 KEY
8"x(3¾"-2")x2¼"

8" END SKEW
(8"-6")x3¾"x2¼"

8" SOAP BRICK
8"x1⅞"x2¼"

8" SIDE SKEW
8"x(3¾"-2⅛")x2¼"

8" EDGE SKEW
8"x(3¾"-1⅜")x2¼"

8" FEATHER EDGE
8"x3¾"x(2¼"-⅛")

STANDARD

TABLE OF 8x3¾x2¼ INCH WEDGE BRICK

Inside Diameter	UNITS REQUIRED PER COURSE No. 2 Wedge	No. 1 Wedge	Straights	Total
2'3"	55	6	.....	61
2'6"	48	16	.....	64
3'0"	40	33	.....	73
3'6"	28	54	.....	82
4'0"	14	76	.....	90
4'6"	2	97	.....	99
5'0"	.....	100	7	107
5'6"	.....	100	16	116
6'0"	.....	100	24	124
6'6"	.....	100	32	132
7'0"	.....	100	41	141
7'6"	.....	100	49	149
8'0"	.....	100	58	158
8'6"	.....	100	66	166
9'0"	.....	100	74	174
9'6"	.....	100	83	183
10'0"	.....	100	91	191
10'6"	.....	100	99	199
11'0"	.....	100	108	208
11'6"	.....	100	116	216
12'0"	.....	100	124	224
12'6"	.....	100	133	233
13'0"	.....	100	141	241
13'6"	.....	100	149	249
14'0"	.....	100	158	258
14'6"	.....	100	166	266
15'0"	.....	100	174	274
15'6"	.....	100	183	283
16'0"	.....	100	192	292
16'6"	.....	100	200	300
17'0"	.....	100	208	308
17'6"	.....	100	217	317
18'0"	.....	100	225	325
18'6"	.....	100	233	333
19'0"	.....	100	242	342
19'6"	.....	100	250	350
20'0"	.....	100	259	359
20'6"	.....	100	267	367
21'0"	.....	100	275	375
21'6"	.....	100	284	384
22'0"	.....	100	292	392
22'6"	.....	100	300	400
23'0"	.....	100	309	409
23'6"	.....	100	317	417
24'0"	.....	100	325	425
24'6"	.....	100	334	434
25'0"	.....	100	342	442

ACID-PROOF BRICK SHAPES

TABLE OF 8x3¾x2¼ INCH ARCH BRICK

Inside Diameter	UNITS REQUIRED PER COURSE No. 1 Arch	No. 2 Arch	No. 3 Arch	Straights	Total
0'6"	.....	.....	19	.....	19
1'0"	.....	22	7	.....	29
1'6"	6	31	.....	.....	37
1'9"	11	30	.....	.....	41
2'0"	19	26	.....	.....	45
2'3"	26	23	.....	.....	49
2'6"	32	21	.....	.....	53
3'0"	44	18	.....	.....	62
3'6"	56	14	.....	.....	70
4'0"	68	10	.....	.....	78
4'3"	76	7	.....	.....	83
4'6"	82	5	.....	.....	87
5'0"	95	.....	.....	.....	95
5'6"	95	.....	.....	8	103
6'0"	95	.....	.....	17	112
6'6"	95	.....	.....	25	120
7'0"	95	.....	.....	33	128
7'6"	95	.....	.....	42	137
8'0"	95	.....	.....	50	145
8'6"	95	.....	.....	58	153
9'0"	95	.....	.....	67	162
9'6"	95	.....	.....	75	170
10'0"	95	.....	.....	83	178
10'6"	95	.....	.....	92	187
11'0"	95	.....	.....	100	195
11'6"	95	.....	.....	109	204
12'0"	95	.....	.....	117	212
12'6"	95	.....	.....	125	220
13'0"	95	.....	.....	134	229
13'6"	95	.....	.....	142	237
14'0"	95	.....	.....	150	245
14'6"	95	.....	.....	159	254

TABLE OF 8x3¾x2¼ INCH KEY BRICK

Inside Diameter	UNITS REQUIRED PER COURSE No. 4 Key	No. 3 Key	No. 2 Key	No. 1 Key	Straights	Total
1'6"	29	.....	.....	.....	.....	29
2'0"	20	15	.....	.....	.....	35
2'6"	10	30	.....	.....	.....	40
3'0"	.....	44	.....	.....	.....	44
3'6"	.....	34	16	.....	.....	50
4'0"	.....	30	25	.....	.....	55
4'6"	.....	19	41	.....	.....	60
5'0"	.....	10	55	.....	.....	65
5'3"	.....	.....	67	.....	.....	67
5'6"	.....	.....	65	5	.....	70
6'0"	.....	.....	60	15	.....	75
6'6"	.....	.....	55	25	.....	80
7'0"	.....	.....	50	35	.....	85
7'6"	.....	.....	45	45	.....	90
8'0"	.....	.....	40	55	.....	95
8'6"	.....	.....	35	65	.....	100
9'0"	.....	.....	30	75	.....	105
9'6"	.....	.....	25	85	.....	110
10'0"	.....	.....	20	95	.....	115
10'6"	.....	.....	15	105	.....	120
11'0"	.....	.....	10	115	.....	125
11'6"	.....	.....	5	125	.....	130
12'0"	.....	.....	.....	135	.....	135
12'6"	.....	.....	.....	135	5	140
13'0"	.....	.....	.....	135	10	145
13'6"	.....	.....	.....	135	15	150
14'0"	.....	.....	.....	135	20	155
14'6"	.....	.....	.....	135	25	160
15'0"	.....	.....	.....	135	30	165
15'6"	.....	.....	.....	135	35	170
16'0"	.....	.....	.....	135	40	175
16'6"	.....	.....	.....	135	45	180
17'0"	.....	.....	.....	135	50	185
17'6"	.....	.....	.....	135	55	190
18'0"	.....	.....	.....	135	60	195
18'6"	.....	.....	.....	135	65	200
19'0"	.....	.....	.....	135	70	205
19'6"	.....	.....	.....	135	75	210
20'0"	.....	.....	.....	135	80	215
20'6"	.....	.....	.....	135	85	220
21'0"	.....	.....	.....	135	90	225
21'6"	.....	.....	.....	135	95	230
22'0"	.....	.....	.....	135	100	235
22'6"	.....	.....	.....	135	105	240
23'0"	.....	.....	.....	135	110	245
23'6"	.....	.....	.....	135	115	250
24'0"	.....	.....	.....	135	120	255
24'6"	.....	.....	.....	135	125	260
25'0"	.....	.....	.....	135	130	265

9"x4½"x2½" SERIES

STANDARD

9" STRAIGHT SERIES
9"x4½"x2½"

No. 1 WEDGE
9"x4½"x(2½"-1⅞")

No. 2 WEDGE
9"x4½"x(2½"-1½")

No. 1 ARCH
9"x4½"x(2½"-2⅛")

No. 2 ARCH
9"x4½"x(2½"-1¾")

No. 3 ARCH
9"x4½"x(2½"-1")

9" SPLIT BRICK
9"x4½"x1¼"

NECK BRICK
9"x4½"x(2½"-⅝")

No. 1 KEY
9"x(4½"-4")x2½"

No. 2 KEY
9"x(4½"-3½")x2½"

No. 3 KEY
9"x(4½"-3")x2½"

No. 4 KEY
9"x(4½"-2¼")x2½"

9" END SKEW
(9"-6¾")x4½"x2½"

9" SOAP BRICK
9"x2¼"x2½"

9" SIDE SKEW
9"x(4½"-2¼")x2½"

9" EDGE SKEW
9"x(4½"-1½")x2½"

9" FEATHER EDGE
9"x4½"x(2½"-⅛")

TABLE OF 9x4½x2½ INCH WEDGE BRICK

UNITS REQUIRED PER COURSE

Inside Diameter	No. 2 Wedge	No. 1 Wedge	Straights	Total
2'3"	57	.....	.....	57
2'6"	49	11	.....	60
3'0"	38	30	.....	68
3'6"	26	50	.....	76
4'0"	12	71	.....	83
4'6"	.....	91	.....	91
5'0"	.....	91	8	99
5'0"	.....	91	8	99
5'6"	.....	91	15	106
6'0"	.....	91	23	114
6'6"	.....	91	30	121
7'0"	.....	91	38	129
7'6"	.....	91	45	136
8'0"	.....	91	53	144
8'6"	.....	91	60	151
9'0"	.....	91	68	159
9'6"	.....	91	76	167
10'0"	.....	91	83	174
10'6"	.....	91	91	182
11'0"	.....	91	98	189
11'6"	.....	91	106	197
12'0"	.....	91	113	204
12'6"	.....	91	121	212
13'0"	.....	91	128	219
13'6"	.....	91	136	227
14'0"	.....	91	143	234
14'6"	.....	91	151	242
15'0"	.....	91	158	249
15'6"	.....	91	166	257
16'0"	.....	91	173	264
16'6"	.....	91	181	272
17'0"	.....	91	188	279
17'6"	.....	91	196	287
18'0"	.....	91	203	294
18'6"	.....	91	211	302
19'0"	.....	91	218	309
19'6"	.....	91	226	317
20'0"	.....	91	233	324
20'6"	.....	91	241	332
21'0"	.....	91	248	339
21'6"	.....	91	256	347
22'0"	.....	91	263	354
22'6"	.....	91	271	362
23'0"	.....	91	278	369
23'6"	.....	91	286	377
24'0"	.....	91	293	384
24'6"	.....	91	301	392
25'0"	.....	91	308	399

ACID-PROOF FIRE CLAY SHAPES

TABLE OF 9x4½x2½ INCH ARCH BRICK

Inside Diameter	No. 1 Arch	No. 2 Arch	No. 3 Arch	Straights	Total
		UNITS REQUIRED PER COURSE			
0'6"	.....	.....	19	.....	19
1'0"	.....	15	12	.....	27
1'6"	.....	30	4	.....	34
1'9"	.....	38	.....	.....	38
2'0"	8	34	.....	.....	42
2'6"	23	26	.....	.....	49
3'0"	38	19	.....	.....	57
3'6"	53	11	.....	.....	64
4'0"	68	4	.....	.....	72
4'3"	76	.....	.....	.....	76
4'6"	76	.....	.....	4	80
5'0"	76	.....	.....	11	87
5'6"	76	.....	.....	19	95
6'0"	76	.....	.....	27	103
6'6"	76	.....	.....	34	110
7'0"	76	.....	.....	42	118
7'6"	76	.....	.....	49	125
8'0"	76	.....	.....	57	133
8'6"	76	.....	.....	64	140
9'0"	76	.....	.....	72	148
9'6"	76	.....	.....	79	155
10'0"	76	.....	.....	87	163
10'6"	76	.....	.....	94	170
11'0"	76	.....	.....	102	178
11'6"	76	.....	.....	109	185
12'0"	76	.....	.....	117	193
12'6"	76	.....	.....	124	200
13'0"	76	.....	.....	132	208
13'6"	76	.....	.....	139	215
14'0"	76	.....	.....	147	223
14'6"	76	.....	.....	154	230

TABLE OF 9x4½x2½ INCH KEY BRICK

Inside Diameter	No. 4 Key	No. 3 Key	No. 2 Key	No. 1 Key	Straights	Total
			UNITS REQUIRED PER COURSE			
1'6"	25	.....	.....	.....	.....	25
2'0"	16	13	.....	.....	.....	29
2'6"	9	25	.....	.....	.....	34
3'0"	.....	38	.....	.....	.....	38
3'6"	.....	29	13	.....	.....	42
4'0"	.....	21	25	.....	.....	46
4'6"	.....	12	38	.....	.....	50
5'0"	.....	5	50	.....	.....	55
5'3"	.....	.....	57	.....	.....	57
5'6"	.....	.....	55	4	.....	59
6'0"	.....	.....	50	13	.....	63
6'6"	.....	.....	46	21	.....	67
7'0"	.....	.....	42	29	.....	71
7'6"	.....	.....	38	38	.....	76
8'0"	.....	.....	34	46	.....	80
8'6"	.....	.....	29	55	.....	84
9'0"	.....	.....	25	63	.....	88
9'6"	.....	.....	21	71	.....	92
10'0"	.....	.....	17	80	.....	97
10'6"	.....	.....	13	88	.....	101
11'0"	.....	.....	9	96	.....	105
11'6"	.....	.....	4	105	.....	109
12'0"	.....	.....	.....	113	.....	113
12'6"	.....	.....	.....	113	4	117
13'0"	.....	.....	.....	113	9	122
13'6"	.....	.....	.....	113	13	126
14'0"	.....	.....	.....	113	17	130
14'6"	.....	.....	.....	113	21	134
15'0"	.....	.....	.....	113	25	138
15'6"	.....	.....	.....	113	30	143
16'0"	.....	.....	.....	113	34	147
16'6"	.....	.....	.....	113	38	151
17'0"	.....	.....	.....	113	42	155
17'6"	.....	.....	.....	113	46	159
18'0"	.....	.....	.....	113	50	163
18'6"	.....	.....	.....	113	55	168
19'0"	.....	.....	.....	113	59	172
19'6"	.....	.....	.....	113	63	176
20'0"	.....	.....	.....	113	67	180
20'6"	.....	.....	.....	113	71	184
21'0"	.....	.....	.....	113	76	189
21'6"	.....	.....	.....	113	80	193
22'0"	.....	.....	.....	113	84	197
22'6"	.....	.....	.....	113	88	201
23'0"	.....	.....	.....	113	92	205
23'6"	.....	.....	.....	113	97	210
24'0"	.....	.....	.....	113	101	214
24'6"	.....	.....	.....	113	105	218
25'0"	.....	.....	.....	113	109	222

The above table may also be used for 9x4½x3 inch Key Brick

ACID-PROOF CIRCLE BRICK

Split Circle Brick

STAGGERED HORIZONTAL JOINTS

CIRCLE BRICK
9"x4½"x2½"

HALF CIRCLE BRICK
4½"x4½"x2½"

PART PLAN 9" WALL

Inner Course full length Circle Brick.

Outer Course full length plus half length Circle Brick.

9x4½x2½ INCH CIRCLE BRICK

Diameter In Inches		4½" Wall	9" Wall	9" Composite	
Inside	Outside	No. of Brick	No. of Brick	No. of Brick	Shape No.
24	33	12			
			12	12	24
			15	12	33
24	42		.....	6	33X
36	45	16			
			16	16	36
			19	16	45
36	54		.....	6	45X
48	57	20			
			20	20	48
			23	20	57
48	66		.....	6	57X
60	69	24			
			24	24	60
			27	24	69
60	78		.....	6	69X
72	81	29			
			29	29	72
			32	28	81
72	90		.....	8	81X
84	93	33			
			33	33	84
			36	32	93
84	102		.....	8	93X
96	105	37			
			37	37	96
			40	36	105
96	114		.....	8	105X
108	117	41			
			41	41	108
			44	40	117
108	126		.....	9	117X
120	129	45			
			45	45	120
			48	44	129
120	138		.....	8	129X

Also available in 8"x3¾"x2¼" and 8"x3¾"x4½" sizes for 3¾" and 7½" thick walls.

STANDARD SHAPES
Used in Tank Construction

• In addition to the brick shapes and sizes shown on pages 26, 27, 28, 29, and 30, the shapes shown at the right often prove desirable in tank construction. These "special" shapes are usually available from stock. On order any desired shape can be furnished. Economy, however, prompts the use of stock shapes and sizes wherever possible.

SUMP BLOCK
(8"-4¾")x3¾"x4½"

BULLNOSE HEADER
8"x2¼"x3¾"

TYPE B SKID BLOCK
12"x6¾"x4¾"
½" Bevel on Curved Ends

BULLNOSE JAMB
8"x3¾"x(2¼"-1")

JET BLOCK
Right- or Left-hand

LINING TILE

"Jennsen" Tile—corrugated edges, clincher back. 9"x18"x(2¼"-1½"). Made in straight face and in radii to fit cylindrical vessels.

Straight and radial lining tile are available in the following sizes: 8"x6"x1½"; 8"x8"x2"; 8"x9"x1½"; 7"x9"x2".

ACID-PROOF BRICKS

STANDARD SHAPES
Used in Floor Construction

● In addition to the brick shapes and sizes shown on pages 26, 27, 28, 29, and 30, the shapes shown below often prove desirable in floor construction. These "special" shapes are usually available from stock. On order any desired shape can be furnished. Economy, however, prompts the use of stock shapes and sizes wherever possible.

SHAPE MB Mat Bottom
8¼"x4"x1⅜"

SHAPE MBT Mat Top and Bottom

SHAPE SB Smooth Bottom
8"x4½"x1¾"

SHAPE GBA Grooved Bottom
8¼"x4"x1⅜"

SHAPE GB Grooved Bottom
8"x4½"x1½"

Shape IC.

Shape EC.

Internal Corners made with Shape IC.

External Corners and Jamb Starters made with Shape EC.

Cove Base with Square External Corner at Top is also available.

BR Bullnose Return
8¼"x4"x1⅜"

BS Bullnose Stretcher
8¼"x4"x1⅜"

CB Cove Base
SCB Square Top Cove Base

BH Bullnose Header
4"x8¼"x1⅜"

CONSTRUCTION

The section following, under the general head "Construction" is not intended to be an engineering textbook in corrosion-resistant masonry design. It was our thought that many of the sketches shown (all representing tested and approved installations) would prove interesting and helpful to design engineers. We hope the somewhat random notes on construction methods, taken from the background of the hundreds of installations we have made, will be of value to both design and construction engineers.

One point about construction we would like to emphasize: all too frequently the construction of corrosion-resistant masonry is looked upon as just another "brick-laying" job, one that can be handled by any "jack-of-all-trades" around the plant. Nothing could be farther from the truth. When you remember that one bad joint may be enough to cause serious damage to the containing walls, you get a better picture of the necessity of using skilled workmen, and of the importance of seeing that they follow the material suppliers' instructions with extreme care. The slight extra construction cost is of minor importance compared to the damage which might be caused through careless workmanship.

The Use of
IMPERVIOUS MEMBRANES WITH BRICK LININGS

With virtually all corrosion-resistant masonry linings, the use of a suitable membrane next to the structural shell is highly desirable. No matter how carefully corrosion-resistant masonry is installed, due to the porosity of the cements or to weakness developed through structural strains, an intermediate corrosion-resistant and fluid-tight barrier is usually necessary to provide adequate corrosion protection for the shell.*

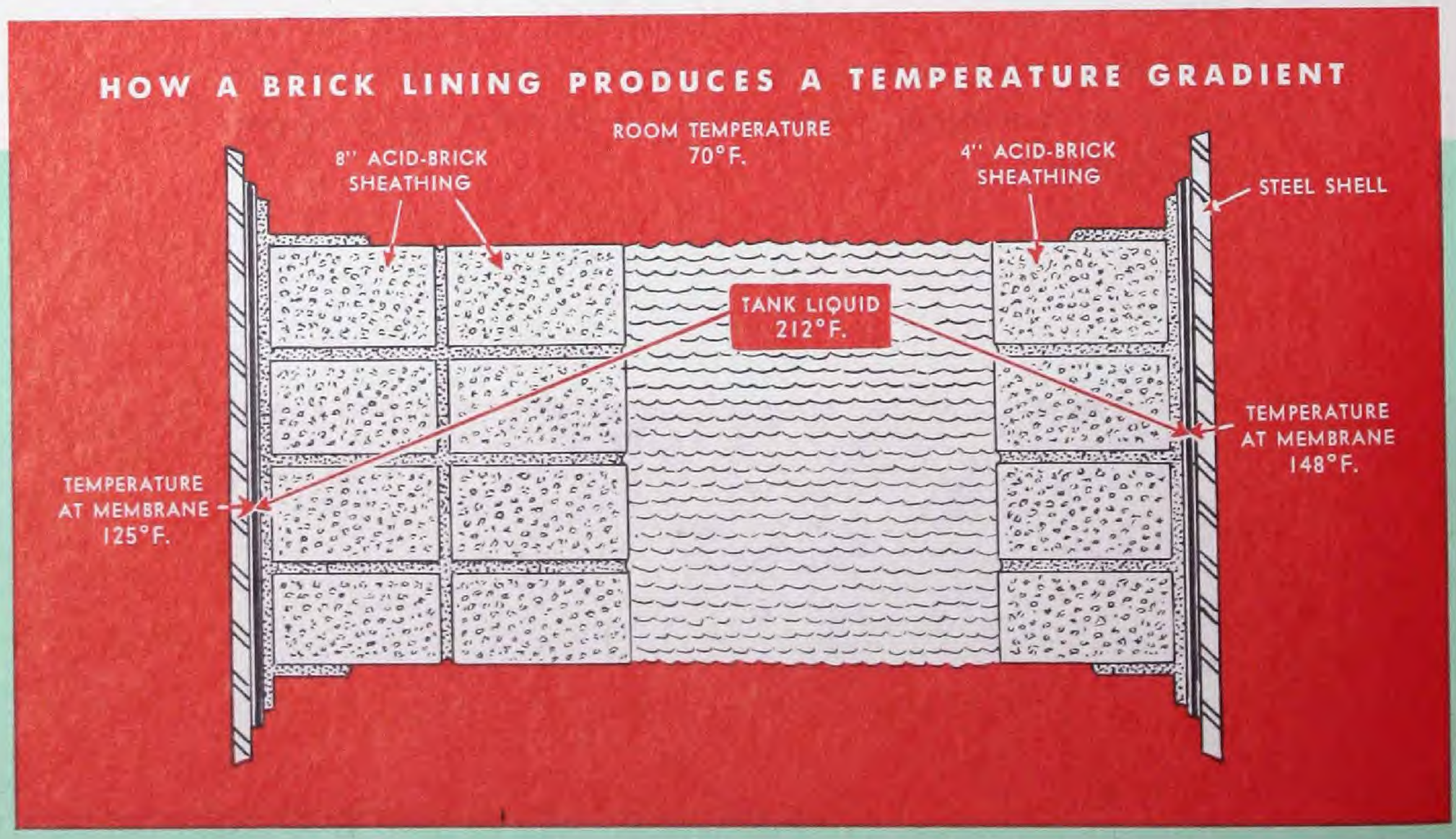
In fact, in almost all cases, the primary function of the corrosion-proof masonry is to act either as a thermal or mechanical protector of the corrosion-proof membrane. The masonry can seldom be thought of as a completely liquid-tight barrier in itself.

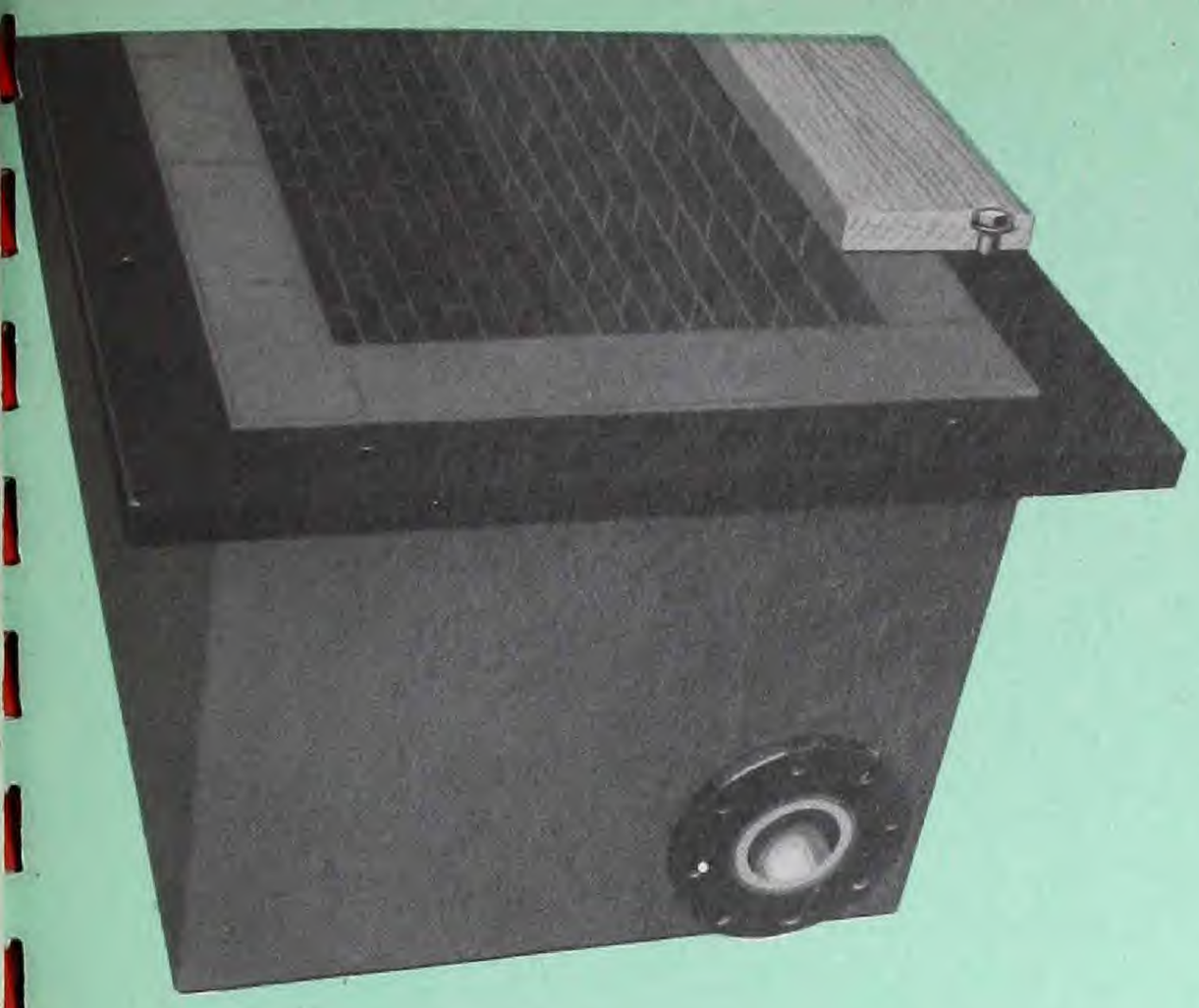
For example, in the case of an acid-proof floor, heavy traffic may crack the acid-proof wearing surface, leaving the membrane as the final protection against attack of the sub floor.

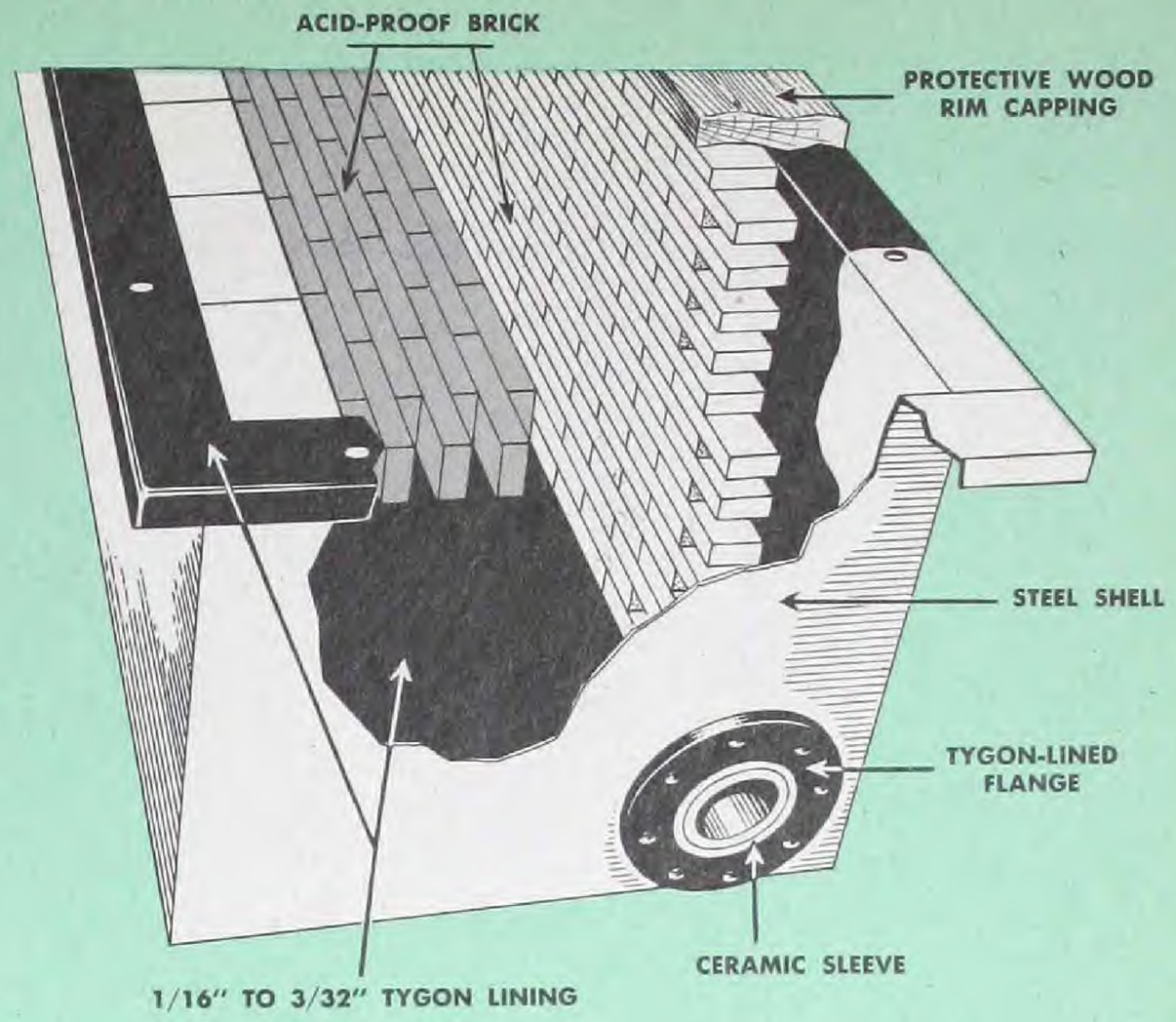
Again, as an over-sheathing for pickling tanks, corrosion-resistant masonry not only serves to protect the membrane from mechanical injury, but will extend the upper temperature limit of the membrane by 60°F, or more. The brick lining serves to produce a temperature gradient. Such a procedure serves, of course, only with a metal shell which will radiate or dissipate heat, and will prove ineffective if the shell be concrete or wood.

Membranes may be of any one of the following materials (ranked in the order of their general range of utility): Tygon, Rubber, Resilon, Lead, Reinforced Asphaltic Materials, Corrosion-Resistant Paint. Final selection depends on the nature of the corrosives to be handled, the length of service required, and initial cost.

**The few exceptions include masonry linings for chrome plating tanks where seepage through the pores of the cement (such as may occur with silicate cements) reacts with the steel to form a passivated film, thus preventing further corrosion.*







Tygon-lined steel tank, oversheathed with one course of acid-brick. Flange protected with ceramic sleeve. Flange and rim are fully covered with Tygon lining. Rim and masonry protected with treated wood planking. Exterior of tank painted with Tygon Paint.

TYGON

Primarily suitable for use as a membrane in welded steel construction. Its use in riveted steel, concrete or wood construction should be considered only after consultation with U. S. Stoneware engineers.

This flexible, rubber-like plastic possesses the greatest general resistance to corrosion of any of the available membrane materials. Tygon will handle 90% or more of the commonly used corrosives, including both oxidizing as well as non-oxidizing acids, alkalies, alcohols, oils, fresh or salt water. Unaffected by oxidation, Tygon linings show no chemical deterioration with age. Initial cost is somewhat greater than rubber, but cost per year of useful life is much less. Tygon bonds without vulcanization so field installations to equipment of large size are entirely feasible. Tygon is suitable for temperatures up to as high as 235°-250°F, when oversheathed.

RUBBER

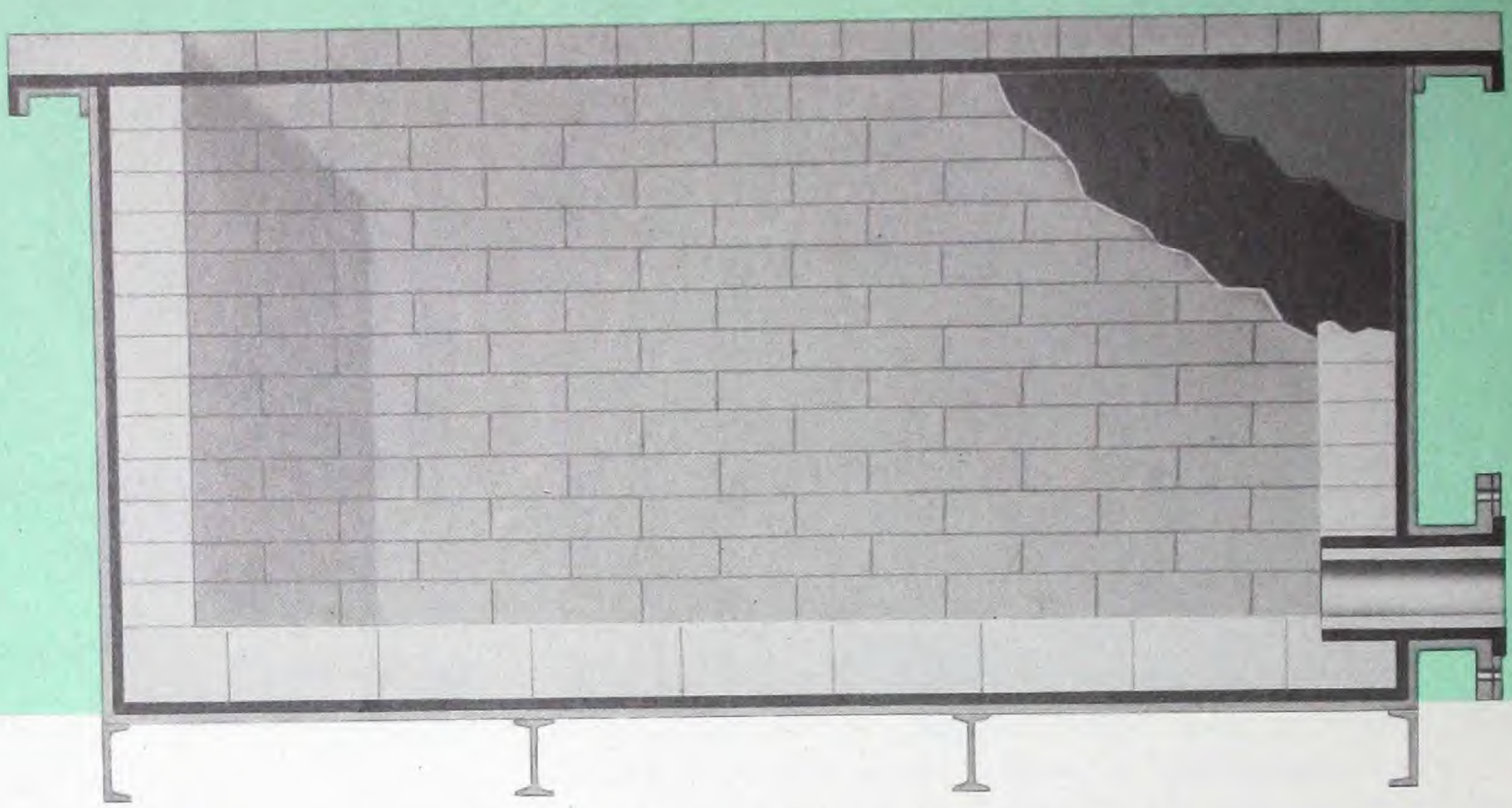
Suitable for use as a membrane material with welded or riveted steel construction. Generally impractical for use with wood or concrete.

Natural and synthetic rubber linings, installed in plies of various thicknesses and vulcanized, show good resistance to most non-oxidizing acids. Unlike Tygon, rubber is subject to oxidation, but generally proves satisfactory where maximum service life is not of major importance. Rubber tends to deteriorate quite rapidly when subjected continuously to temperatures in excess of 150°F.

RESILON

Suitable for use as a membrane material with welded or riveted steel, or concrete construction.

Resilon is an ideal material where low first cost and ease of installation are of first consideration. Resilon possesses excellent resistance to non-oxidizing acids over a temperature range comparable to rubber. Resilon is applied in sheet form (by your own workmen if desired) to the structural shell, without curing. Standard Resilon sheets are 30″ x 48″ x ⅜″. Or, for use as a membrane in floor construction, bulk Resilon may be melted and applied (hot) by mop or trowel. The cost of a Resilon membrane, installed, is less than half that of rubber.



Typical construction rectangular steel tank. Membrane may be Tygon, Resilon, rubber or lead. Ceramic or lead sleeve.

LEAD (sheet)

Suitable for use with welded or riveted steel, wood, or concrete construction.

Sheet lead is a low-cost membrane frequently specified for use with corrosives to which lead is resistant, where temperature changes are held to narrow limits. Under alternate heating and cooling sheet lead expands, shows a tendency to grow, may buckle and eventually crack not only the lead itself but the masonry oversheath.

LEAD (homogeneously bonded)

For use with welded or riveted steel construction only.

Where lead is applied to the steel shell by the Republic homogeneous bonding process (fused to the steel) it becomes an integral part of the shell and will withstand expansion and contraction of the shell without growing, buckling or cracking.

REINFORCED ASPHALTIC COMPOUNDS

Suitable for use with welded or riveted steel, concrete or wood construction.

Such low cost membranes (of which ordinary tar paper is typical) find their greatest use in corrosion-resistant floor construction. It is generally considered advisable to mop such a membrane thoroughly with a liquid asphaltic compound, or with hot Resilon, before laying the brick work.

CORROSION-RESISTANT PAINTS

Where need for a membrane is not absolutely essential but where it may be desirable to protect the structural shell from normal atmospheric oxidation or from attack by very weak chemical solutions, multiple coats of a corrosion-resistant paint, such as Tygon Paint, may be used effectively.

GASKETS

It is always necessary to use full gaskets on all connections such as flanges, manhole covers, etc., in order to avoid any leakage through the containing walls. It proves helpful to carry a stock of Tygon sheet gasketing material on hand for just such purposes.

U. S. Stoneware engineers will be glad to suggest suitable membranes when fully acquainted with information regarding the proposed usage.

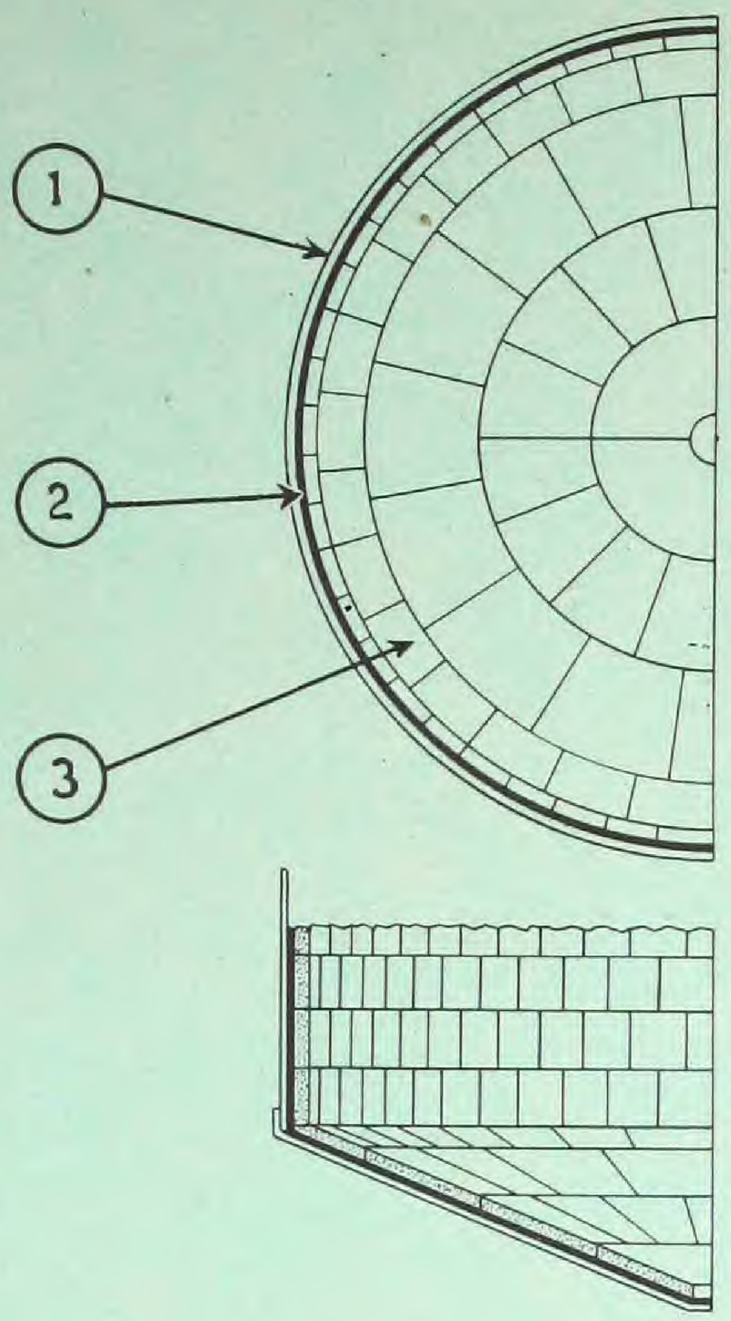
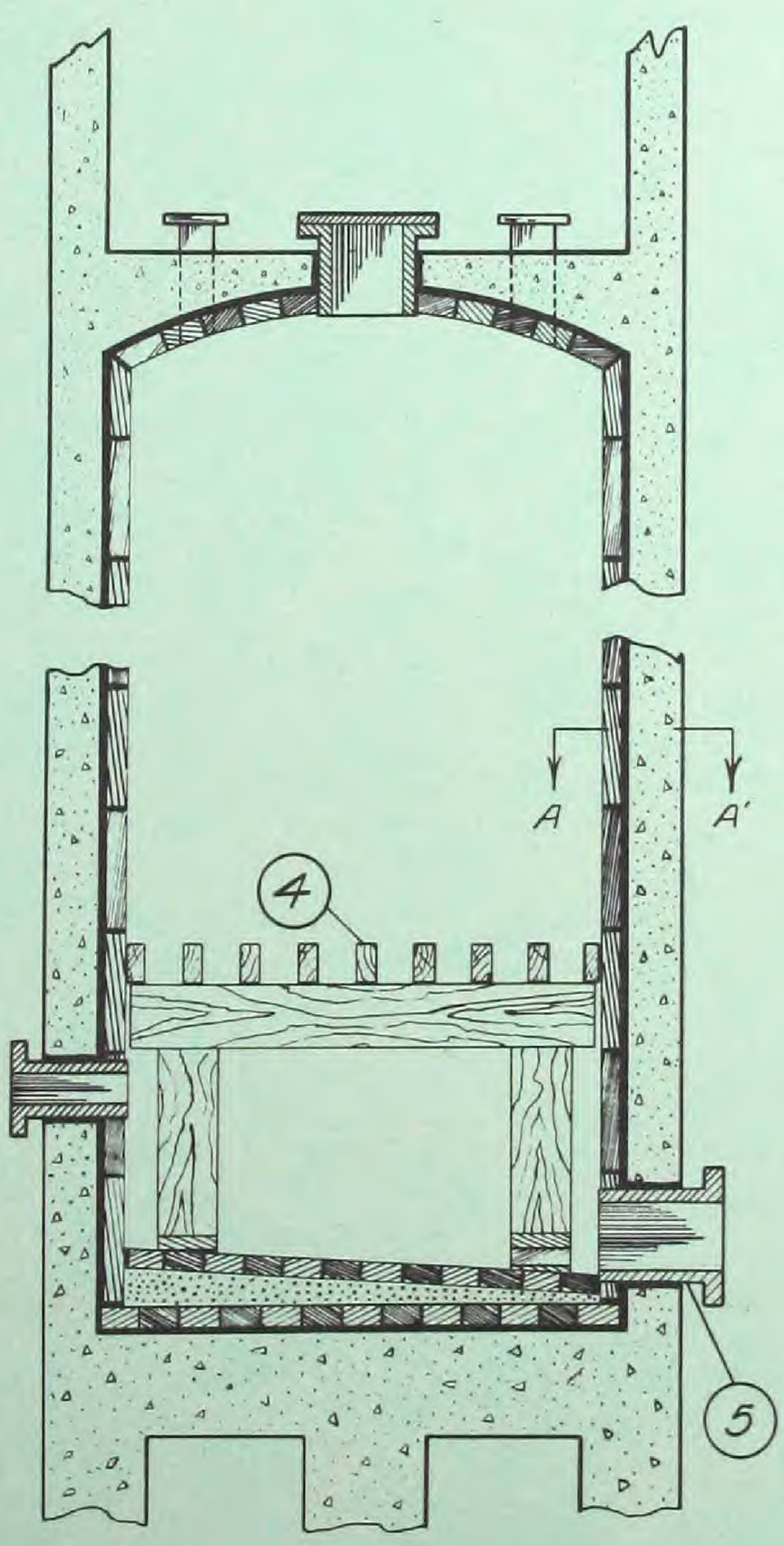
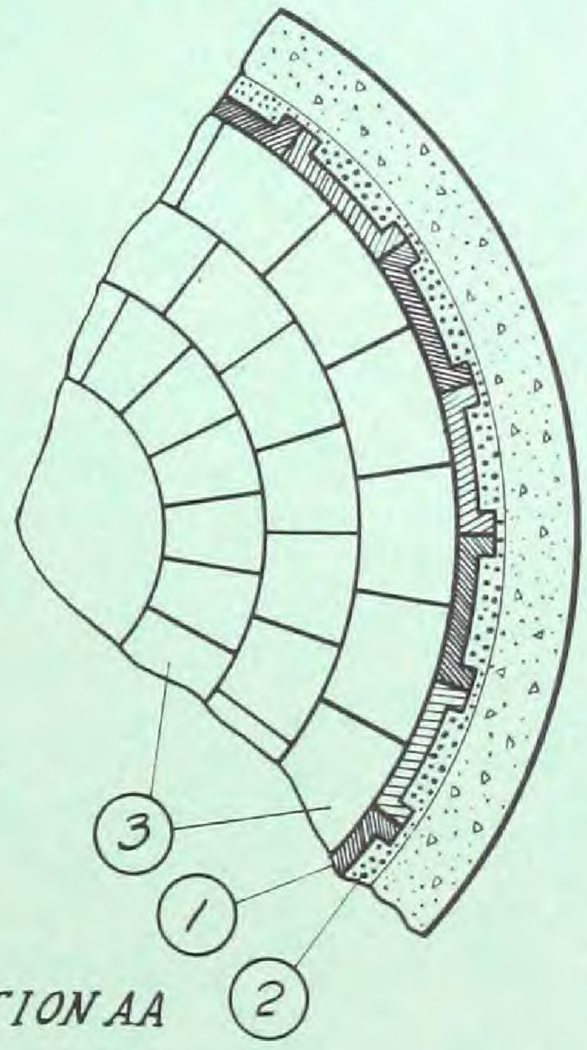


Fig. 506

Cylindrical Steel Shell Lined with Special Shaped Acid Brick

(1) Metallic casing
(2) Membrane
(3) Acid-proof brick linings





SECTION AA

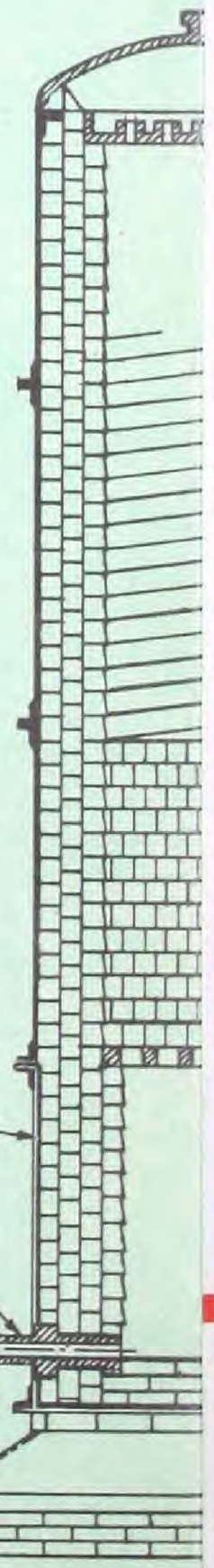


Figure 7-L—Acid Absorption or Scrubbing Tower

(1) Acid-Proof radial-shaped tile ("Jenssen" Shape)
(2) Acid-proof cement grout
(3) Chemical-ware radial brick floor and dome
(4) Racks (design optional)
(5) Clean-out

Section AA'—Lining section detail showing plan of radial brick on floor and dome

ONSTRUCTION

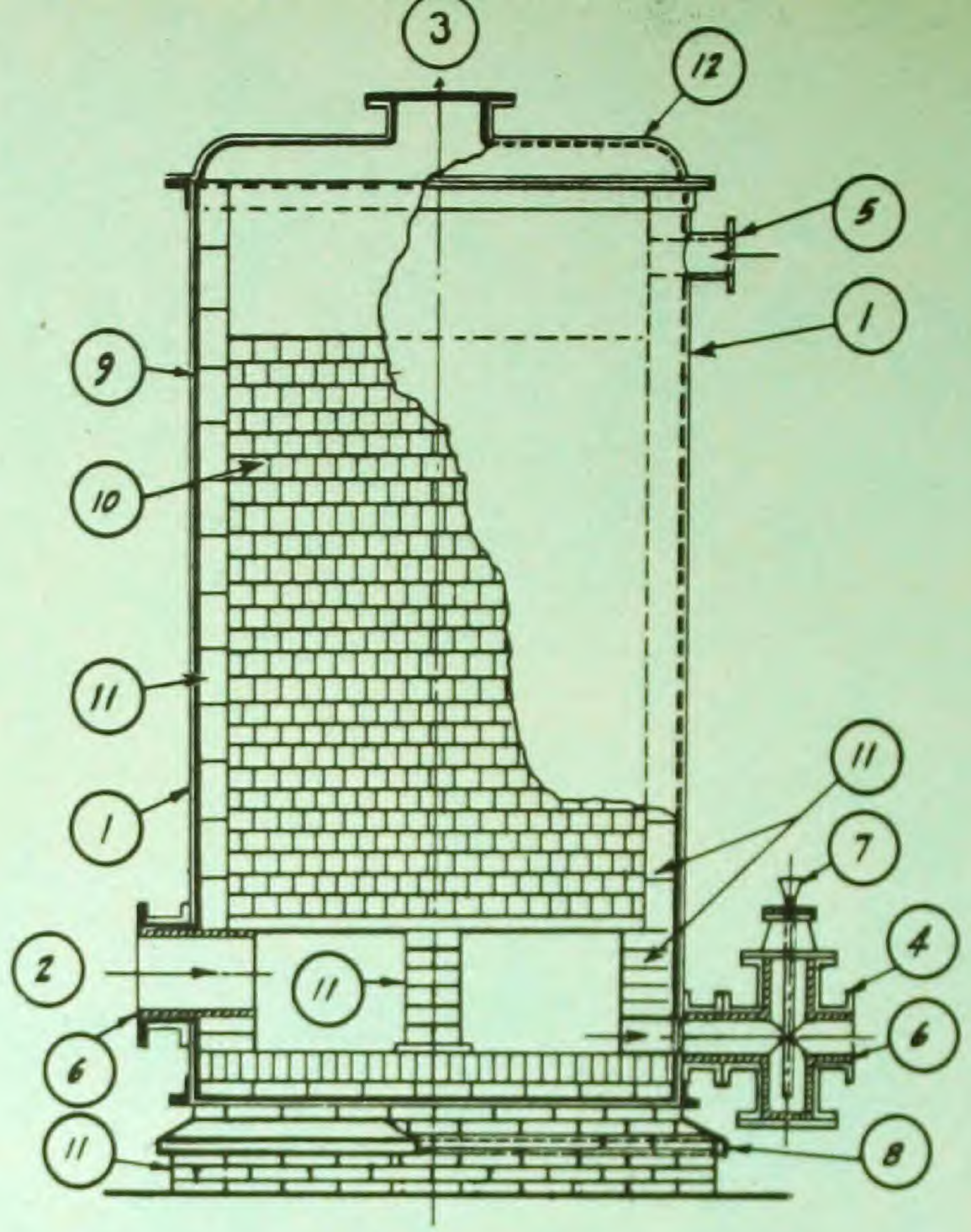


Figure 4-L—Acid-Spray Tower with Metallic Inlet and Outlet Connections Lined with Chemical Ware

(1) Metallic casing
(2) Gas connection
(3) Gas connection
(4) Acid outlet connection
(5) Acid connection
(6) Chemical-ware pipe lining
(7) Diluting tube
(8) Drip pan
(9) Membrane
(10) Packing rings
(11) Acid-proof brick linings
(12) Metallic cover

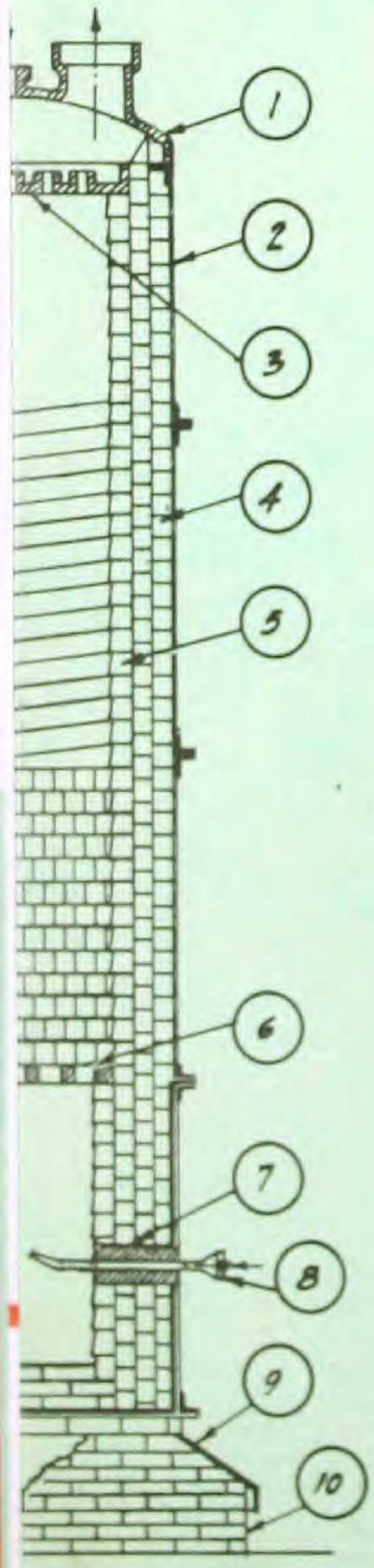


Figure 1-L—Denitrating Tower with Triple Lining, Set Inside of a Metallic Casing

(1) Chemical-ware cover
(2) Metallic casing
(3) Chemical-ware distributor
(4) Radial brick lining
(5) Acid-proof radial brick, spirally set, minimizing the capillary flow
(6) Chemical-ware grill
(7) Special block
(8) Steam jet
(9) Drip pan
(10) Acid-proof brick base
(11) Outlet connection
(12) Membrane

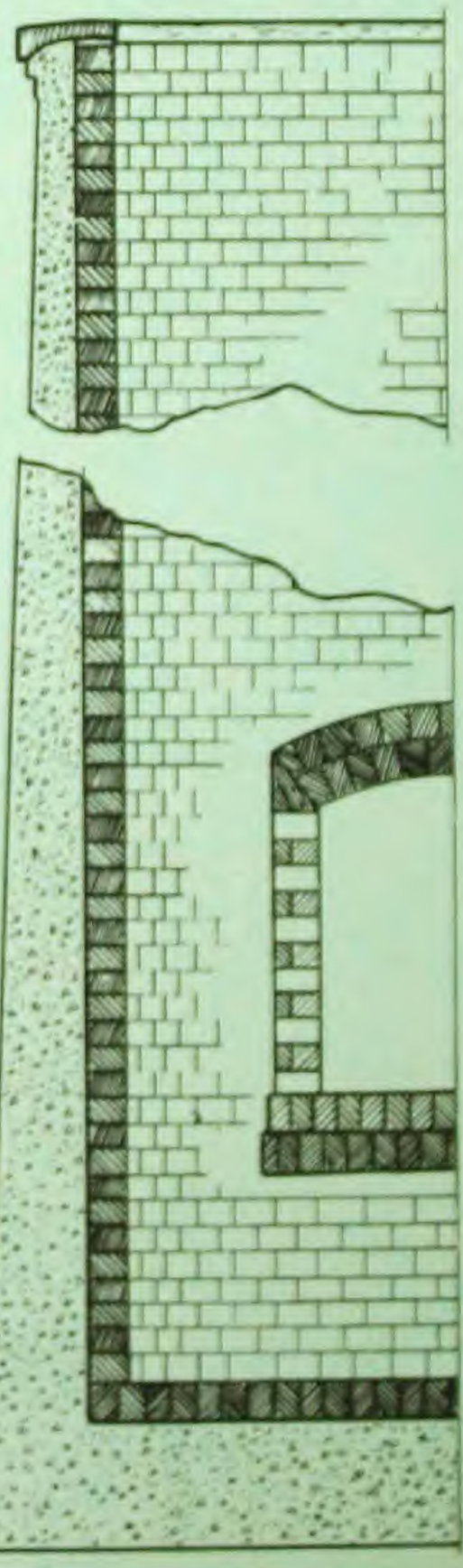
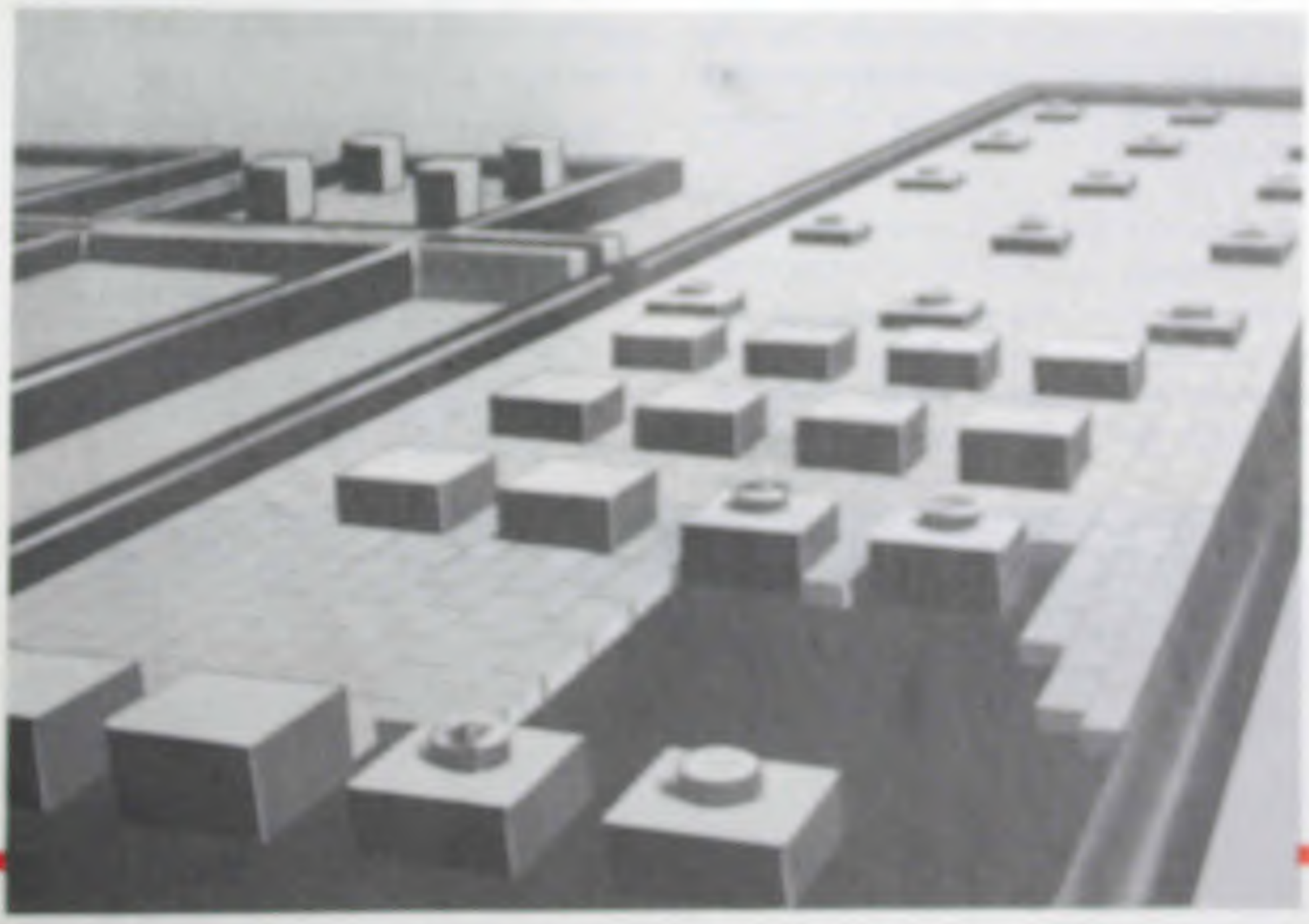


Figure 6-L
Stack with Bonded Chemical-ware Lining for Corrosive Gases

Acid-Proof
FLOOR CONSTRUCTION

The problems involved in corrosion-resistant floor construction are so many and so varied that it is difficult and hazardous to attempt to set up an outline of a standard procedure that will prove effective in all cases. So many factors aside from the materials used influence and affect the life of floors: the amount of traffic, the load, the impact, the presence of oil or water, the acids, alkalies, or solvents used, and their concentration, the presence or absence of thermal shock, the location of the floor—whether ground level or upper story. However, the floor construction described on the next page comes as close to providing an ideal corrosion-resistant floor as any we know.



Acid-proof floor construction for use under heavy steel tanks. Brick is bonded with Duriron cement throughout. Membrane is Karnak. Localized curb construction, such as this, saves cost and weight.

CONSTRUCTION

Outlined below is the procedure, which we have found from experience gives, generally, the most satisfactory floor:

1 Start with a rigid, solid base. The ideal base is rigid concrete, 3″ to 4″ thick, even thicker if traffic conditions are severe.

2 Cover the concrete base with several layers of tar paper.* All posts, curbs, drains, etc., should be carefully flashed in — just as carefully as if you were preparing a roof.

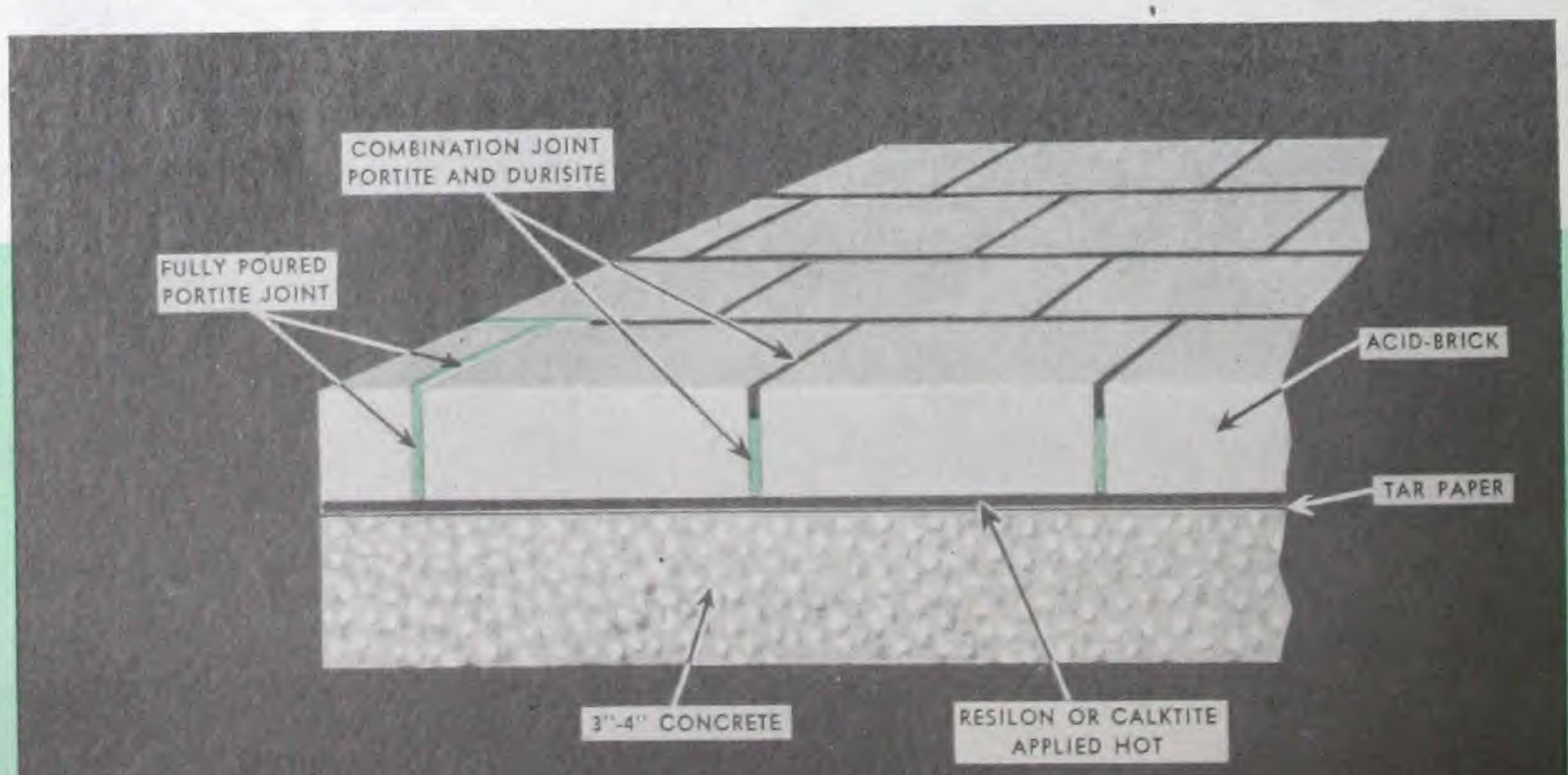
3 Mop the entire area with either Resilon or Calktite. Don't be stingy, use plenty of Resilon or Calktite and see that it covers. Remember that due to traffic shocks masonry portions of the floor may crack, and it is particularly important that the membrane beneath be carefully prepared and capable of preventing sub surface seepage.

4 Lay the floor with acid-proof brick, allowing ¼″ joint space between the brick, and place the roughened, non-skid surface out. Thickness of the brick depends on traffic conditions—for light traffic the minimum should be 1⅛″; for heavy duty traffic, 2¼″. It is rare that more than one course is required. Refer to Section on Acid Brick.

5 Bond the acid-proof brick with Portite, Carbo-Portite, or Super-Portite by pouring the cement (hot) into the joints. Depending on the service conditions, the joint may be a completely poured joint or may be a combination joint. For the latter, fill the joints with Portite to within ⅝″ or ½″ of the top — no more. Point the rest of the joint with Durisite Cement. Pack the cement into the joint tightly so no possibility of voids exists. To secure a smooth joint dip the trowel in Durisite Solution before stroking.

**In some cases, where corrosive conditions are unusually severe, we have found it advisable to use Tygon, rubber or lead instead of multiplied coated paper, as a membrane.*

NOTE: For corrosion-resistant floors which must be built on other than a rigid base, or where other factors prevent the use of acid brick, a special mastic flooring of Resilon and quartz, or a Tygon sheet flooring may be used. For additional details write Engineering Department, The U. S. Stoneware Co., Akron, Ohio.



Random
CONSTRUCTION NOTES

EXPANSION JOINTS

Expansion joints are indicated in virtually all sheathed tanks operating at elevated temperatures and having any horizontal dimension exceeding 15 to 20 feet. Design and placement of these joints is a problem that should be referred to the engineering department of the material supplier.

COMBINATION CONSTRUCTION

In many cases combinations of cements offer not only the least expensive but the ideal construction as well. Frequently acid-proof brick are laid in silicate cements with the surface joint being left open to a depth of ½". After the silicate cement has set, it is neutralized by a 5% to 10% solution of HCL, after which the joint recesses are pointed with Durisite resin cement.

Similarly a combination of Portite and Durisite often proves advisable. In a two-course construction the surface course may be bonded with Durisite and Portite poured in to fill the back joints. Durisite thus acts as a seal to prevent leakage of the molten Portite, and the hot Portite speeds up the cure of Durisite.

REPAIRS

Silicate Cements: Usually require local neutralization. Where brickwork has been saturated with acids, clean faulty places with a 5% solution of caustic soda and wash with water. Repeat several times. No acid should be allowed to touch the repair work before the cement sets. **Durisite:** Neutralize acid surfaces with 5% solution of caustic soda, wash, and dry thoroughly. Alkaline surfaces with 5%-10% HCL solution. Wash, and dry thoroughly. **Portite:** Hot Portite bonds homogeneously with cold Portite, but in large areas care must be exercised lest stress be built up by contraction of the hot compound on the cold.

IMPORTANCE OF THIN JOINTS

Joints made with either silicate cements or Durisite should be kept as thin as possible not only to minimize shrinkage and to lessen danger of washout (with silicate cements), but also to obtain the strongest possible joint, and, too, from a standpoint of economy. Corrosion-resistant cements cost substantially more per unit of volume than acid-proof brick. *Keep joints thin—preferably not more than ⅛".* With a poured joint of Portite, ⅛" joints are impractical. A joint of ¼" is preferred. Likewise with combination joints, either of silicate cement and Durisite, or of Portite and Durisite, a joint of ¼" offers greater assurance of a fully-packed, tight joint.

USE OF SPACING CHIPS WITH PORTITE

Masonry wall construction with sulphur type cements is speeded up by the use of ¼" Portite spacing chips. The brick are placed on chips with the exposed face of the brick covered with paper. This procedure provides a uniform joint and the paper prevents the joint from running out as it is poured.

EXTERIOR PROTECTION

To protect the exposed surface on the outside of a steel, wood, or concrete tank from deterioration from acid drip or slop over, or from fumes or condensation, it is wise to apply a few coats of Tygon Paint. This easily applied liquid coating (a formulation of the basic Tygon sheet stocks used as a corrosion-proof membrane) provides excellent protection against almost all acids and alkalies.

FLOOR CLEARANCE

It is advisable when possible (particularly with pickling tanks) to set the tank on piers with sufficient floor clearance to permit painting underneath and to prevent corrosive damage to the bottom of the tank from spillage creeping between the floor and tank.

HEATING

In heating a brick-lined tank it is necessary to avoid impingement of steam on the masonry. If a jet heater is used it is advisable to set it on a localized pad of brickwork which can be readily replaced without affecting the brick lining.

VAULTED CONSTRUCTION

On tanks of a depth of four feet or more both sides and ends should be given a slope of at least 2".

SINGLE OR DOUBLE COURSE SHEATHING

Keeping in mind the double purpose of brick sheathing: (1) to provide a temperature gradient for the membrane, and (2) to protect the membrane from mechanical abuse, the number of courses will depend on solution temperature and on the likelihood of mechanical damage.

RIM CAPPING

Cappings of brick, or of Tygon-painted wood, to protect the rim and flange from mechanical abuse are highly advisable.

PREPARATION OF STEEL SHELLS

Preferably steel shells should be welded rather than riveted construction. Not only is application of linings or membranes to riveted shells difficult and expensive but possibility of early failure is far greater. Our own specifications for shells which we fabricate or have fabricated are quite rigid. Excerpts from those specifications covering "construction" and "welding" may prove helpful:

CONSTRUCTION

(a) Tanks or welded parts shall be fabricated in accordance with standardized commercial practice to obtain a practical product and uniform quality.

(b) The companion angles of sectional pieces which are bolted together must be square, plumb, and smooth, and sections must fit exactly when bolted together. The open ends of sectional items shall be provided with suitable bracing so they will not become distorted in transit. Sectional items shall be permanently match marked on spots that are not to be Tygon covered to accurately indicate their position when assembled. Parts must line up properly when correctly assembled and marked.

(c) Fabricator to supply necessary bolts, nuts and washers to complete any assembly.

(d) Dished surfaces are to be flanged in such a manner as to eliminate wrinkles at the knuckle radius.

WELDING

(a) All joints over which Tygon is to be applied must be continuous solid welded.

(b) All welds must be smooth with no porosity, holes, high spots, lumps or pockets. Peening is required to eliminate porosity, and grinding to remove sharp edges and high spots.

(c) All corners are to be ground to a minimum radius of 1/8".

(d) Partitions, braces, supports, or other attachments on the inside of the tank must be fitted flat against the adjacent surface and full welded from all sides. Spot welding is not permissible. (Welds to be ground per (c) above.)

(e) All body seams must be butt welded, with continuous solid welding throughout.

(f) Misalignment of plates and butt weld seams not to exceed 25% of plate thickness and in no case to exceed 1/8".

INSPECTION

Whenever opportunity permits careful inspection should be made of all joints to detect any signs of erosion. Eroded joints should be repointed promptly.

CAPACITY OF VERTICAL CYLINDRICAL TANKS PER FOOT OF DEPTH

Diameter Ft.	In.	Volume Cu. Ft.	Gallons U. S.	Gallons Imperial
1	0	.79	5.87	4.89
	3	1.23	9.18	7.64
	6	1.77	13.22	11.01
	9	2.41	17.99	14.98
2	0	3.14	23.50	19.57
	3	3.98	29.74	24.77
	6	4.91	36.72	30.58
	9	5.94	44.43	37.00
3	0	7.07	52.88	44.03
	3	8.30	62.06	51.67
	6	9.62	71.97	59.93
	9	11.05	82.62	69.89
4	0	12.57	94.00	78.27
	6	15.90	118.97	99.06
5	0	19.64	146.88	122.30
	6	23.76	177.72	147.98
6	0	28.27	211.51	176.11
	6	33.18	248.23	206.69
7	0	38.49	287.88	239.71
	6	44.18	330.48	275.18
8	0	50.27	376.01	313.09
	6	56.75	424.48	353.45
9	0	63.62	475.89	396.25
	6	70.88	530.24	441.50
10	0	78.54	587.52	489.20
	6	86.59	647.74	539.35
11	0	95.03	710.90	591.93
	6	103.87	776.99	646.98
12	0	113.10	846.03	704.45
	6	122.72	918.00	764.38
13	0	132.73	992.91	826.74
	6	143.14	1070.8	891.56
14	0	153.94	1151.5	958.85
	6	165.13	1235.3	1028.6
15		176.72	1321.9	1100.7
16		201.06	1504.1	1252.4
17		226.98	1697.9	1413.2
18		254.47	1903.6	1585.0
19		283.53	2108.0	1766.0
20		314.16	2350.1	1956.2
21		346.36	2591.0	2157.4
22		380.13	2843.6	2367.7
23		415.48	3108.0	2587.9
24		452.39	3384.1	2817.8
25		490.87	3672.0	3057.5
26		530.93	3971.6	3307.0
27		572.56	4283.0	3566.3
28		615.75	4606.2	3835.4
29		660.52	4941.0	4114.3
30		706.86	5287.7	4402.8
31		754.77	5646.1	4701.2
32		804.25	6016.2	5009.4
33		855.30	6398.1	5327.4
34		907.92	6791.7	5655.3
35		962.11	7197.1	5992.9
36		1017.9	7614.4	6340.0
37		1075.2	8043.1	6697.1
38		1134.1	8483.7	7064.0
39		1194.6	8936.2	7440.7
40		1256.6	9400.0	7827.2

Diameter Ft.	Volume Cu. Ft.	Gallons U. S.	Gallons Imperial
41	1320.3	9877	8223
42	1385.4	10364	8630
43	1452.2	10863	9045
44	1520.5	11374	9471
45	1590.3	11897	9906
46	1661.9	12432	10352
47	1734.9	12978	10806
48	1809.6	13537	11271
49	1885.7	14106	11746
50	1963.5	14688	12230
51	2042.8	15281	12724
52	2123.7	15886	13228
53	2206.2	16504	13742
54	2290.2	17132	14265
55	2375.8	17772	14798
56	2463.0	18425	15341
57	2551.8	19088	15894
58	2642.1	19764	16457
59	2734.0	20451	17029
60	2827.4	21150	17611
61	2922.5	21862	18203
62	3019.1	22584	18805
63	3117.3	23318	19414
64	3217.0	24064	20038
65	3318.3	24822	20669
66	3421.2	25592	21309
67	3525.7	26373	21960
68	3631.7	27167	22621
69	3739.3	27972	23291
70	3848.5	28789	23971
71	3959.2	29617	24661
72	4071.5	30456	25360
73	4185.4	31309	26069
74	4300.8	32172	26789
75	4417.9	33048	27518
76	4536.4	33935	28256
77	4656.6	34834	29005
78	4778.4	35744	29763
79	4901.7	36668	30531
80	5026.5	37601	31309
81	5153.0	38548	32097
82	5281.0	39504	32894
83	5410.6	40475	33702
84	5541.8	41456	34518
85	5674.5	42448	35345
86	5808.8	43453	36182
87	5944.7	44469	37028
88	6082.1	45497	37884
89	6221.1	46537	38750
90	6361.7	47588	39625
91	6503.9	48652	40511
92	6647.6	49728	41406
93	6792.9	50814	42311
94	6939.8	51914	43226
95	7088.2	53023	44150
96	7238.2	54145	45085
97	7389.8	55279	46029
98	7543.0	56426	46984
99	7697.6	57584	47948
100	7854.0	58751	48920

TABLE OF CIRCLES

Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.	Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.	Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.
				5	0	15.708	19.6350	10	0	31.416	78.540
0	1	.262	.0055		1	15.970	20.2949		1	31.678	79.854
	2	.524	.0218		2	16.232	20.9658		2	31.940	81.180
	3	.785	.0491		3	16.493	21.6475		3	32.201	82.516
	4	1.047	.0873		4	16.755	22.3402		4	32.463	83.863
	5	1.309	.1364		5	17.017	23.0438		5	32.725	85.221
	6	1.571	.1964		6	17.279	23.7583		6	32.987	86.590
	7	1.833	.2673		7	17.541	24.4837		7	33.249	87.970
	8	2.094	.3491		8	17.802	25.2200		8	33.510	89.361
	9	2.356	.4418		9	18.064	25.9672		9	33.772	90.763
	10	2.618	.5454		10	18.326	26.7254		10	34.034	92.175
	11	2.880	.6600		11	18.588	27.4944		11	34.296	93.599
1	0	3.142	.7854	6	0	18.850	28.2743	11	0	34.558	95.033
	1	3.403	.9218		1	19.111	29.0652		1	34.819	96.479
	2	3.665	1.0690		2	19.373	29.8670		2	35.081	97.935
	3	3.927	1.2272		3	19.635	30.6796		3	35.343	99.402
	4	4.189	1.3963		4	19.897	31.5032		4	35.605	100.880
	5	4.451	1.5763		5	20.159	32.3377		5	35.867	102.369
	6	4.712	1.7672		6	20.420	33.1831		6	36.128	103.869
	7	4.974	1.9690		7	20.682	34.0394		7	36.390	105.380
	8	5.236	2.1817		8	20.944	34.9066		8	36.652	106.901
	9	5.498	2.4053		9	21.206	35.7847		9	36.914	108.434
	10	5.760	2.6398		10	21.468	36.6737		10	37.176	109.978
	11	6.021	2.8853		11	21.729	37.5737		11	37.437	111.532
2	0	6.283	3.1416	7	0	21.991	38.4845	12	0	37.699	113.097
	1	6.545	3.4089		1	22.253	39.4063		1	37.961	114.674
	2	6.807	3.6870		2	22.515	40.3389		2	38.223	116.261
	3	7.069	3.9761		3	22.777	41.2825		3	38.485	117.859
	4	7.330	4.2761		4	23.038	42.2370		4	38.746	119.468
	5	7.592	4.5869		5	23.300	43.2024		5	39.008	121.088
	6	7.854	4.9087		6	23.562	44.1787		6	39.270	122.719
	7	8.116	5.2414		7	23.824	45.1659		7	39.532	124.360
	8	8.378	5.5851		8	24.086	46.1640		8	39.794	126.013
	9	8.639	5.9396		9	24.347	47.1730		9	40.055	127.676
	10	8.901	6.3050		10	24.609	48.1929		10	40.317	129.351
	11	9.163	6.6813		11	24.871	49.2237		11	40.579	131.036
3	0	9.425	7.0686	8	0	25.133	50.2655	13	0	40.841	132.733
	1	9.687	7.4667		1	25.395	51.3181		1	41.103	134.439
	2	9.948	7.8758		2	25.656	52.3817		2	41.364	136.158
	3	10.210	8.2958		3	25.918	53.4562		3	41.626	137.887
	4	10.472	8.7267		4	26.180	54.5415		4	41.888	139.626
	5	10.734	9.1684		5	26.442	55.6378		5	42.150	141.377
	6	10.996	9.6211		6	26.703	56.7450		6	42.412	143.139
	7	11.257	10.0847		7	26.965	57.8631		7	42.673	144.911
	8	11.519	10.5592		8	27.227	58.9921		8	42.935	146.695
	9	11.781	11.0447		9	27.489	60.1321		9	43.197	148.489
	10	12.043	11.5410		10	27.751	61.2829		10	43.459	150.295
	11	12.305	12.0482		11	28.013	62.4446		11	43.721	152.111
4	0	12.566	12.5664	9	0	28.274	63.6173	14	0	43.982	153.938
	1	12.828	13.0954		1	28.536	64.8008		1	44.244	155.776
	2	13.090	13.6354		2	28.798	65.9953		2	44.506	157.626
	3	13.352	14.1863		3	29.060	67.2006		3	44.768	159.485
	4	13.614	14.7480		4	29.322	68.4169		4	45.029	161.356
	5	13.875	15.3207		5	29.583	69.6441		5	45.291	163.237
	6	14.137	15.9043		6	29.845	70.8822		6	45.553	165.130
	7	14.399	16.4988		7	30.107	72.1312		7	45.815	167.034
	8	14.661	17.1042		8	30.369	73.3911		8	46.077	168.948
	9	14.923	17.7206		9	30.631	74.6619		9	46.338	170.873
	10	15.184	18.3478		10	30.892	75.9436		10	46.600	172.809
	11	15.446	18.9859		11	31.154	77.2363		11	46.862	174.757

TABLE OF CIRCLES

Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.	Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.	Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.
15	0	47.124	176.715	20	0	62.832	314.159	25	0	78.540	490.874
	1	47.386	178.684		1	63.094	316.783		1	78.802	494.152
	2	47.647	180.663		2	63.355	319.417		2	79.063	497.441
	3	47.909	182.654		3	63.617	322.062		3	79.325	500.740
	4	48.171	184.656		4	63.879	324.719		4	79.587	504.051
	5	48.433	186.668		5	64.141	327.386		5	79.849	507.373
	6	48.695	188.692		6	64.403	330.064		6	80.111	510.705
	7	48.956	190.726		7	64.664	332.753		7	80.372	514.049
	8	49.218	192.772		8	64.926	335.452		8	80.634	517.403
	9	49.480	194.828		9	65.188	338.163		9	80.896	520.768
	10	49.742	196.895		10	65.450	340.882		10	81.158	524.144
	11	50.004	198.973		11	65.712	343.617		11	81.420	527.531
16	0	50.265	201.062	21	0	65.973	346.361	26	0	81.681	530.929
	1	50.527	203.162		1	66.235	349.115		1	81.913	534.338
	2	50.789	205.273		2	66.497	351.880		2	82.205	537.758
	3	51.051	207.394		3	66.759	354.656		3	82.467	541.188
	4	51.313	209.527		4	67.021	357.443		4	82.729	544.630
	5	51.574	211.670		5	67.282	360.241		5	82.990	548.083
	6	51.836	213.825		6	67.544	363.050		6	83.252	551.546
	7	52.098	215.990		7	67.806	365.870		7	83.514	555.020
	8	52.360	218.166		8	68.068	368.701		8	83.776	558.505
	9	52.622	220.353		9	68.330	371.542		9	84.038	562.002
	10	52.883	222.551		10	68.591	374.395		10	84.299	565.509
	11	53.145	224.760		11	68.853	377.258		11	84.561	569.026
17	0	53.407	226.980	22	0	69.115	380.133	27	0	84.823	572.555
	1	53.669	229.211		1	69.377	383.018		1	85.085	576.095
	2	53.931	231.453		2	69.639	385.914		2	85.347	579.646
	3	54.192	233.705		3	69.900	388.821		3	85.608	583.207
	4	54.454	235.969		4	70.162	391.739		4	85.870	586.780
	5	54.716	238.243		5	70.424	394.668		5	86.132	590.363
	6	54.978	240.528		6	70.686	397.608		6	86.394	593.957
	7	55.240	242.824		7	70.948	400.559		7	86.656	597.563
	8	55.501	245.132		8	71.209	403.520		8	86.917	601.179
	9	55.763	247.450		9	71.471	406.493		9	87.179	604.806
	10	56.025	249.778		10	71.733	409.476		10	87.441	608.444
	11	56.287	252.118		11	71.995	412.470		11	87.703	612.092
18	0	56.549	254.469	23	0	72.257	415.476	28	0	87.965	615.752
	1	56.810	256.831		1	72.518	418.492		1	88.226	619.423
	2	57.072	259.203		2	72.780	421.519		2	88.488	623.104
	3	57.334	261.587		3	73.042	424.557		3	88.750	626.797
	4	57.596	263.981		4	73.304	427.606		4	89.012	630.500
	5	57.858	266.386		5	73.566	430.665		5	89.274	634.215
	6	58.119	268.803		6	73.827	433.736		6	89.535	637.940
	7	58.381	271.230		7	74.089	436.818		7	89.797	641.676
	8	58.643	273.668		8	74.351	439.910		8	90.059	645.423
	9	58.905	276.117		9	74.613	443.014		9	90.321	649.181
	10	59.167	278.576		10	74.875	446.128		10	90.583	652.950
	11	59.428	281.047		11	75.136	449.253		11	90.844	656.729
19	0	59.690	283.529	24	0	75.398	452.389	29	0	91.106	660.520
	1	59.952	286.021		1	75.660	455.536		1	91.368	664.321
	2	60.214	288.525		2	75.922	458.694		2	91.630	668.134
	3	60.476	291.039		3	76.184	461.863		3	91.892	671.957
	4	60.737	293.564		4	76.445	465.043		4	92.153	675.792
	5	60.999	296.101		5	76.707	468.234		5	92.415	679.637
	6	61.261	298.648		6	76.969	471.435		6	92.677	683.493
	7	61.523	301.206		7	77.231	474.647		7	92.939	687.360
	8	61.785	303.775		8	77.493	477.871		8	93.201	691.238
	9	62.046	306.354		9	77.754	481.106		9	93.462	695.127
	10	62.308	308.945		10	78.016	484.351		10	93.724	699.026
	11	62.570	311.547		11	78.278	487.607		11	93.986	702.937

TABLE OF CIRCLES

Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.	Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.	Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.
30	0	94.25	706.858	35	0	109.96	962.11	40	0	125.66	1256.64
	1	94.51	710.791		1	110.22	966.70		1	125.93	1261.88
	2	94.77	714.734		2	110.48	971.30		2	126.19	1267.13
	3	95.03	718.688		3	110.74	975.91		3	126.45	1272.39
	4	95.29	722.654		4	111.00	980.53		4	126.71	1277.67
	5	95.56	726.630		5	111.26	985.16		5	126.97	1282.95
	6	95.82	730.617		6	111.53	989.80		6	127.23	1288.25
	7	96.08	734.615		7	111.78	994.45		7	127.50	1293.56
	8	96.34	738.623		8	112.05	999.11		8	127.76	1298.87
	9	96.60	742.643		9	112.31	1003.79		9	128.02	1304.20
	10	96.87	746.674		10	112.57	1008.47		10	128.28	1309.54
	11	97.12	750.715		11	112.84	1013.17		11	128.54	1314.89
31	0	97.40	754.768	36	0	113.10	1017.88	41	0	128.81	1320.25
	1	97.65	758.831		1	113.36	1022.59		1	129.07	1325.63
	2	97.91	762.905		2	113.62	1027.32		2	129.33	1331.01
	3	98.17	766.990		3	113.88	1032.06		3	129.59	1336.40
	4	98.44	771.087		4	114.14	1036.81		4	129.85	1341.81
	5	98.70	775.193		5	114.40	1041.57		5	130.11	1347.23
	6	98.96	779.311		6	114.67	1046.35		6	130.38	1352.65
	7	99.22	783.440		7	114.93	1051.13		7	130.64	1358.09
	8	99.48	787.580		8	115.19	1055.92		8	130.90	1363.54
	9	99.75	791.730		9	115.45	1060.73		9	131.16	1368.99
	10	100.01	795.892		10	115.72	1065.55		10	131.42	1374.47
	11	100.27	800.064		11	115.98	1070.37		11	131.69	1379.95
32	0	100.53	804.248	37	0	116.24	1075.21	42	0	131.95	1385.44
	1	100.79	808.442		1	116.50	1080.06		1	132.21	1390.95
	2	101.05	812.647		2	116.76	1084.92		2	132.47	1396.46
	3	101.32	816.863		3	117.02	1089.79		3	132.73	1401.98
	4	101.58	821.090		4	117.29	1094.67		4	132.99	1407.52
	5	101.84	825.328		5	117.55	1099.56		5	133.26	1413.07
	6	102.10	829.577		6	117.81	1104.47		6	133.52	1418.63
	7	102.36	833.837		7	118.07	1109.38		7	133.78	1424.19
	8	102.63	838.107		8	118.33	1114.31		8	134.04	1429.77
	9	102.89	842.389		9	118.60	1119.24		9	134.30	1435.36
	10	103.15	846.681		10	118.86	1124.19		10	134.56	1440.97
	11	103.41	850.984		11	119.12	1129.15		11	134.83	1446.58
33	0	103.67	855.299	38	0	119.38	1134.11	43	0	135.09	1452.20
	1	103.93	859.624		1	119.64	1139.09		1	135.35	1457.84
	2	104.20	863.960		2	119.90	1144.09		2	135.61	1463.48
	3	104.46	868.307		3	120.17	1149.09		3	135.87	1469.14
	4	104.72	872.665		4	120.43	1154.10		4	136.14	1474.80
	5	104.98	877.033		5	120.69	1159.12		5	136.40	1480.48
	6	105.24	881.413		6	120.95	1164.16		6	136.66	1486.17
	7	105.51	885.804		7	121.21	1169.20		7	136.92	1491.87
	8	105.77	890.205		8	121.47	1174.26		8	137.18	1497.58
	9	106.03	894.618		9	121.74	1179.32		9	137.44	1503.30
	10	106.29	899.041		10	121.99	1184.40		10	137.71	1509.03
	11	106.55	903.475		11	122.26	1189.49		11	137.97	1514.78
34	0	106.81	907.920	39	0	122.52	1194.59	44	0	138.23	1520.53
	1	107.08	912.376		1	122.78	1199.70		1	138.49	1526.30
	2	107.34	916.843		2	123.05	1204.82		2	138.75	1532.07
	3	107.60	921.321		3	123.31	1209.96		3	139.02	1537.86
	4	107.86	925.810		4	123.57	1215.10		4	139.28	1543.66
	5	108.12	930.310		5	123.83	1220.25		5	139.54	1549.47
	6	108.38	934.820		6	124.09	1225.42		6	139.80	1555.28
	7	108.65	939.342		7	124.35	1230.59		7	140.06	1561.12
	8	108.91	943.874		8	124.62	1235.78		8	140.32	1566.96
	9	109.17	948.417		9	124.88	1240.98		9	140.59	1572.81
	10	109.43	952.971		10	125.14	1246.19		10	140.85	1578.67
	11	109.69	957.537		11	125.40	1251.41		11	141.11	1584.55

TABLE OF CIRCLES

Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.	Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.	Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.
45	0	141.37	1590.43	50	0	157.08	1963.50	55	0	172.79	2375.83
	1	141.63	1596.33		1	157.34	1970.05		1	173.05	2383.03
	2	141.90	1602.23		2	157.60	1976.61		2	173.31	2390.25
	3	142.16	1608.15		3	158.87	1983.18		3	173.57	2397.48
	4	142.42	1614.08		4	158.13	1989.76		4	173.83	2404.71
	5	142.68	1620.02		5	158.39	1996.36		5	174.10	2411.96
	6	142.94	1625.97		6	158.65	2002.96		6	174.36	2419.22
	7	143.20	1631.93		7	158.91	2009.58		7	174.62	2426.49
	8	143.47	1637.90		8	159.17	2016.20		8	174.88	2433.77
	9	143.73	1643.89		9	159.44	2022.84		9	175.14	2441.07
	10	143.99	1649.88		10	159.70	2029.49		10	175.41	2448.37
	11	144.25	1655.89		11	159.96	2036.15		11	175.67	2455.68
46	0	144.51	1661.90	51	0	160.22	2042.82	56	0	175.93	2463.01
	1	144.78	1667.93		1	160.48	2049.50		1	176.19	2470.34
	2	145.03	1673.97		2	160.74	2056.19		2	176.45	2477.69
	3	145.30	1680.02		3	161.01	2062.90		3	176.71	2485.05
	4	145.56	1686.07		4	161.27	2069.61		4	176.98	2492.42
	5	145.82	1692.15		5	161.53	2076.34		5	177.24	2499.80
	6	146.08	1698.23		6	161.79	2083.07		6	177.50	2507.19
	7	146.35	1704.32		7	162.05	2089.82		7	177.76	2514.59
	8	146.61	1710.42		8	162.32	2096.58		8	178.02	2522.00
	9	146.87	1716.54		9	162.58	2103.35		9	178.29	2529.42
	10	147.13	1722.66		10	162.84	2110.12		10	178.55	2536.86
	11	147.39	1728.80		11	163.10	2116.92		11	178.81	2544.30
47	0	147.65	1734.94	52	0	163.36	2123.72	57	0	179.07	2551.76
	1	147.92	1741.10		1	163.62	2130.53		1	179.33	2559.23
	2	148.18	1747.27		2	163.89	2137.35		2	179.59	2566.70
	3	148.44	1753.45		3	164.15	2144.19		3	179.86	2574.19
	4	148.70	1759.64		4	164.41	2151.03		4	180.12	2581.69
	5	148.96	1765.84		5	164.67	2157.89		5	180.38	2589.20
	6	149.23	1772.05		6	164.93	2164.75		6	180.64	2596.72
	7	149.49	1778.28		7	165.20	2171.63		7	180.90	2604.25
	8	149.75	1784.51		8	165.46	2178.52		8	181.17	2611.80
	9	150.01	1790.76		9	165.72	2185.42		9	181.43	2619.35
	10	150.27	1797.01		10	165.98	2192.33		10	181.69	2626.92
	11	150.53	1803.28		11	166.24	2199.25		11	181.95	2634.49
48	0	150.80	1809.56	53	0	166.50	2206.18	58	0	182.21	2642.08
	1	151.06	1815.85		1	166.77	2213.13		1	182.47	2649.68
	2	151.32	1822.15		2	167.03	2220.08		2	182.74	2657.29
	3	151.58	1828.46		3	167.29	2227.05		3	183.00	2664.91
	4	151.84	1834.78		4	167.55	2234.02		4	183.26	2672.54
	5	152.11	1841.11		5	167.81	2241.01		5	183.52	2680.18
	6	152.37	1847.45		6	168.08	2248.01		6	183.78	2687.83
	7	152.63	1853.81		7	168.34	2255.01		7	184.05	2695.49
	8	152.89	1860.17		8	168.60	2262.03		8	184.31	2703.17
	9	153.15	1866.55		9	168.86	2269.06		9	184.57	2710.85
	10	153.41	1872.93		10	169.12	2276.11		10	184.83	2718.55
	11	153.68	1879.33		11	169.38	2283.16		11	185.09	2726.25
49	0	153.94	1885.74	54	0	169.65	2290.22	59	0	185.35	2733.97
	1	154.20	1892.16		1	169.91	2297.30		1	185.62	2741.70
	2	154.46	1898.59		2	170.17	2304.38		2	185.88	2749.44
	3	154.72	1905.03		3	170.43	2311.48		3	186.14	2757.19
	4	154.99	1911.48		4	170.69	2318.58		4	186.40	2764.95
	5	155.25	1917.95		5	170.96	2325.70		5	186.66	2772.72
	6	155.51	1924.42		6	171.22	2332.83		6	186.92	2780.51
	7	155.77	1930.91		7	171.48	2339.97		7	187.19	2788.30
	8	156.03	1937.40		8	171.74	2347.12		8	187.45	2796.10
	9	156.29	1943.91		9	172.00	2354.28		9	187.71	2803.92
	10	156.56	1950.43		10	172.26	2361.45		10	187.97	2811.75
	11	156.82	1956.96		11	172.53	2368.64		11	188.23	2819.58

TABLE OF CIRCLES

Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.	Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.	Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.
60	0	188.50	2827.43	65	0	204.20	3318.31	70	0	219.91	3848.45
	1	188.76	2835.29		1	204.47	3326.82		1	220.17	3857.62
	2	189.02	2843.16		2	204.73	3335.35		2	220.44	3866.80
	3	189.28	2851.04		3	204.99	3343.88		3	220.70	3875.99
	4	189.54	2858.94		4	205.25	3352.43		4	220.96	3885.19
	5	189.80	2866.84		5	205.51	3360.99		5	221.22	3894.40
	6	190.07	2874.75		6	205.77	3369.55		6	221.48	3903.63
	7	190.33	2882.68		7	206.04	3378.13		7	221.74	3912.86
	8	190.59	2890.61		8	206.30	3386.72		8	222.01	3922.10
	9	190.85	2898.56		9	206.56	3395.33		9	222.27	3931.36
	10	191.11	2906.52		10	206.82	3403.94		10	222.53	3940.63
	11	191.38	2914.49		11	207.08	3412.56		11	222.79	3949.90
61	0	191.64	2922.47	66	0	207.35	3421.19	71	0	223.05	3959.19
	1	191.90	2930.46		1	207.61	3429.84		1	223.31	3968.49
	2	192.16	2938.46		2	207.87	3438.50		2	223.58	3977.80
	3	192.42	2946.47		3	208.13	3447.16		3	223.84	3987.12
	4	192.68	2954.49		4	208.39	3455.84		4	224.10	3996.45
	5	192.95	2962.53		5	208.65	3464.53		5	224.36	4005.80
	6	193.21	2970.57		6	208.92	3473.23		6	224.62	4015.15
	7	193.47	2978.63		7	209.18	3481.94		7	224.89	4024.52
	8	193.73	2986.69		8	209.44	3490.66		8	225.15	4033.89
	9	193.99	2994.77		9	209.70	3499.39		9	225.41	4043.28
	10	194.26	3002.86		10	209.96	3508.13		10	225.67	4052.68
	11	194.52	3010.96		11	210.22	3516.89		11	225.93	4062.08
62	0	194.78	3019.07	67	0	210.49	3525.65	72	0	226.19	4071.50
	1	195.04	3027.19		1	210.75	3534.43		1	226.46	4080.93
	2	195.30	3035.32		2	211.01	3543.21		2	226.72	4090.38
	3	195.56	3043.47		3	211.27	3552.01		3	226.98	4099.83
	4	195.83	3051.62		4	211.53	3560.82		4	227.24	4109.29
	5	196.09	3059.79		5	211.80	3569.64		5	227.50	4118.76
	6	196.35	3067.96		6	212.06	3578.47		6	227.77	4128.25
	7	196.61	3076.15		7	212.32	3587.31		7	228.03	4137.74
	8	196.87	3084.35		8	212.58	3596.16		8	228.29	4147.25
	9	197.13	3092.55		9	212.84	3605.03		9	228.55	4156.77
	10	197.40	3100.77		10	213.10	3613.90		10	228.81	4166.30
	11	197.66	3109.00		11	213.37	3622.79		11	229.07	4175.84
63	0	197.92	3117.25	68	0	213.63	3631.68	73	0	229.34	4185.39
	1	198.18	3125.50		1	213.89	3640.59		1	229.60	4194.95
	2	198.44	3133.76		2	214.15	3649.51		2	229.86	4204.52
	3	198.71	3142.03		3	214.41	3658.43		3	230.12	4214.10
	4	198.97	3150.32		4	214.68	3667.37		4	230.38	4223.70
	5	199.23	3158.62		5	214.94	3676.32		5	230.65	4233.30
	6	199.49	3166.92		6	215.20	3685.28		6	230.91	4242.92
	7	199.75	3175.24		7	215.46	3694.26		7	231.17	4252.54
	8	200.01	3183.57		8	215.72	3703.24		8	231.43	4262.18
	9	200.28	3191.91		9	215.98	3712.23		9	231.69	4271.83
	10	200.54	3200.26		10	216.25	3721.24		10	231.95	4281.49
	11	200.80	3208.62		11	216.51	3730.25		11	232.22	4291.16
64	0	201.06	3216.99	69	0	216.77	3739.28	74	0	232.48	4300.84
	1	201.32	3225.37		1	217.03	3748.32		1	232.74	4310.53
	2	201.59	3233.77		2	217.29	3757.37		2	233.00	4320.24
	3	201.85	3242.17		3	217.56	3766.43		3	233.26	4329.95
	4	202.11	3250.59		4	217.82	3775.50		4	233.53	4339.67
	5	202.37	3259.02		5	218.08	3784.58		5	233.79	4349.41
	6	202.63	3267.45		6	218.34	3793.67		6	234.05	4359.16
	7	202.89	3275.90		7	218.60	3802.77		7	234.31	4368.91
	8	203.16	3284.36		8	218.86	3811.89		8	234.57	4378.68
	9	203.42	3292.83		9	219.13	3821.01		9	234.83	4388.46
	10	203.68	3301.31		10	219.39	3830.15		10	235.10	4398.25
	11	203.94	3309.80		11	219.65	3839.29		11	235.36	4408.05

TABLE OF CIRCLES

Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.	Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.	Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.
75	0	235.62	4417.86	80	0	251.33	5026.55	85	0	267.04	5674.50
	1	235.88	4427.69		1	251.59	5037.03		1	267.30	5685.63
	2	236.14	4437.52		2	251.85	5047.51		2	267.56	5696.78
	3	236.40	4447.37		3	252.11	5058.01		3	267.82	5707.93
	4	236.67	4457.22		4	252.37	5068.52		4	268.08	5719.09
	5	236.93	4467.09		5	252.64	5079.04		5	268.34	5730.27
	6	237.19	4476.97		6	252.90	5089.58		6	268.61	5741.46
	7	237.45	4486.85		7	253.16	5100.12		7	268.87	5752.65
	8	237.71	4496.75		8	253.42	5110.67		8	269.13	5763.86
	9	237.98	4506.66		9	253.68	5121.24		9	269.39	5775.08
	10	238.24	4516.58		10	253.95	5131.81		10	269.65	5786.31
	11	238.50	4526.52		11	254.21	5142.40		11	269.92	5797.55
76	0	238.76	4536.46	81	0	254.47	5152.99	86	0	270.18	5808.80
	1	239.02	4546.41		1	254.73	5163.61		1	270.44	5820.07
	2	239.28	4556.38		2	254.99	5174.22		2	270.70	5831.34
	3	239.55	4566.35		3	255.25	5184.86		3	270.96	5842.63
	4	239.81	4576.34		4	255.52	5195.50		4	271.22	5853.92
	5	240.07	4586.34		5	255.78	5206.15		5	271.49	5865.23
	6	240.33	4596.35		6	256.04	5216.81		6	271.75	5876.55
	7	240.59	4606.37		7	256.30	5227.48		7	272.01	5887.87
	8	240.86	4616.40		8	256.56	5238.17		8	272.27	5899.21
	9	241.12	4626.44		9	256.83	5248.87		9	272.53	5910.56
	10	241.38	4636.49		10	257.09	5259.57		10	272.80	5921.92
	11	241.64	4646.55		11	257.35	5270.29		11	273.06	5933.30
77	0	241.90	4656.63	82	0	257.61	5281.02	87	0	273.32	5944.68
	1	242.16	4666.71		1	257.87	5291.76		1	273.58	5956.07
	2	242.43	4676.81		2	258.13	5302.51		2	273.84	5967.48
	3	242.69	4686.91		3	258.40	5313.27		3	274.10	5978.89
	4	242.95	4697.03		4	258.66	5324.04		4	274.37	5990.32
	5	243.21	4707.16		5	258.92	5334.82		5	274.63	6001.76
	6	243.47	4717.30		6	259.18	5345.62		6	274.89	6013.20
	7	243.74	4727.45		7	259.44	5356.42		7	275.15	6024.66
	8	243.99	4737.61		8	259.71	5367.24		8	275.41	6036.13
	9	244.26	4747.78		9	259.97	5378.06		9	275.67	6047.61
	11	244.52	4757.96		10	260.23	5388.90		10	275.94	6059.11
	11	244.78	4768.16		11	260.49	5399.75		11	276.20	6070.61
78	0	245.04	4778.36	83	0	260.75	5410.61	88	0	276.46	6082.12
	1	245.31	4788.58		1	261.01	5421.48		1	276.72	6093.65
	2	245.57	4798.80		2	261.28	5432.36		2	276.98	6105.18
	3	245.83	4809.04		3	261.54	5443.25		3	277.25	6116.73
	4	246.09	4819.29		4	261.80	5454.15		4	277.51	6128.29
	5	246.35	4829.55		5	262.06	5465.07		5	277.77	6139.86
	6	246.62	4839.82		6	262.32	5475.99		6	278.03	6151.43
	7	246.88	4850.10		7	262.58	5486.93		7	278.29	6163.02
	8	247.14	4860.39		8	262.85	5497.87		8	278.55	6174.63
	9	247.40	4870.70		9	263.11	5508.83		9	278.82	6186.24
	10	247.66	4881.01		10	263.37	5519.80		10	279.08	6197.86
	11	247.92	4891.33		11	263.63	5530.78		11	279.34	6209.49
79	0	248.19	4901.67	84	0	263.89	5541.77	89	0	279.60	6221.14
	1	248.45	4912.02		1	264.16	5552.77		1	279.86	6232.79
	2	248.71	4922.37		2	264.42	5563.78		2	280.13	6244.46
	3	248.97	4932.74		3	264.68	5574.81		3	280.39	6256.14
	4	249.23	4943.12		4	264.94	5585.84		4	280.65	6267.83
	5	249.49	4953.51		5	265.20	5596.88		5	280.91	6279.53
	6	249.76	4963.91		6	265.46	5607.94		6	281.17	6291.24
	7	250.02	4974.32		7	265.73	5619.01		7	281.43	6302.96
	8	250.28	4984.75		8	265.99	5630.08		8	281.70	6314.69
	9	250.54	4995.18		9	266.25	5641.17		9	281.96	6326.43
	10	250.80	5005.63		10	266.51	5652.27		10	282.22	6338.19
	11	251.07	5016.08		11	266.77	5663.38		11	282.48	6349.95

TABLE OF CIRCLES

Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.	Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.	Diameter Ft.	In.	Circum. Feet	Area Sq. Ft.
90	0	282.74	6361.73	93	5	293.48	6853.91	96	9	303.95	7351.77
	1	283.01	6373.51		6	293.74	6866.15		10	304.21	7364.44
	2	283.53	6385.31		7	294.00	6878.39		11	304.47	7377.12
	3	382.53	6397.12		8	294.26	6890.65	97	0	304.73	7389.81
	4	283.79	6408.94		9	294.52	6902.91		1	305.00	7402.51
	5	284.05	6420.77		10	294.79	6915.19		2	305.26	7415.23
	6	284.31	6432.61		11	295.05	6927.48		3	305.52	7427.95
	7	284.58	6444.46	94	0	295.31	6939.78		4	305.78	7440.69
	8	284.84	6456.32		1	295.57	6952.09		5	306.04	7453.43
	9	285.10	6468.20		2	295.83	6964.41		6	306.31	7466.19
	10	285.36	6480.08		3	296.10	6976.74		7	306.57	7478.96
	11	285.62	6491.98		4	296.36	6989.08		8	306.83	7491.74
91	0	285.88	6503.88		5	296.62	7001.44		9	307.09	7504.53
	1	286.15	6515.80		6	296.88	7013.80		10	307.35	7517.33
	2	286.41	6527.73		7	297.14	7026.18		11	307.61	7530.14
	3	286.67	6539.67		8	297.40	7038.56	98	0	307.88	7542.96
	4	286.93	6551.62		9	297.67	7050.96		1	308.14	7555.80
	5	287.19	6563.58		10	297.93	7063.37		2	308.40	7568.64
	6	287.46	6575.55		11	298.19	7075.79		3	308.66	7581.50
	7	287.72	6587.53	95	0	298.45	7088.22		4	308.92	7594.36
	8	287.98	6599.53		1	298.71	7100.66		5	309.19	7607.24
	9	288.24	6611.53		2	298.97	7113.11		6	309.45	7620.13
	10	288.50	6623.55		3	299.24	7125.57		7	309.71	7633.03
	11	288.76	6635.57		4	299.50	7138.05		8	309.97	7645.94
92	0	289.03	6647.61		5	299.76	7150.53		9	310.23	7658.86
	1	289.29	6659.66		6	300.02	7163.03		10	310.49	7671.79
	2	289.55	6671.72		7	300.28	7175.53		11	310.76	7684.73
	3	289.81	6683.79		8	300.55	7188.05	99	0	311.02	7697.69
	4	290.07	6695.87		9	300.81	7200.58		1	311.28	7710.65
	5	290.34	6707.96		10	301.07	7213.12		2	311.54	7723.63
	6	290.60	6720.06		11	301.33	7225.67		3	311.80	7736.61
	7	290.86	6732.18	96	0	301.59	7238.23		4	312.06	7749.61
	8	291.12	6744.30		1	301.85	7250.80		5	312.33	7762.62
	9	291.38	6756.44		2	302.12	7263.38		6	312.59	7775.64
	10	291.64	6768.58		3	302.38	7275.98		7	312.85	7788.67
	11	291.91	6780.74		4	302.64	7288.58		8	313.11	7801.71
93	0	292.17	6792.91		5	302.90	7301.20		9	313.37	7814.76
	1	292.43	6805.09		6	303.16	7313.82		10	313.64	7827.82
	2	292.69	6817.28		7	303.43	7326.46		11	313.90	7840.90
	3	292.95	6829.48		8	303.69	7339.11	100	0	314.16	7853.98
	4	293.22	6841.69								

TABLE OF SPHERES

DIAMETERS BY FRACTIONS

Diameter	Volume	Area	Diameter	Volume	Area	Diameter	Volume	Area
1/32	.00002	.003068	1 1/16	.6280	3.5466	2 9/16	8.810	20.6290
1/16	.00013	.012272	1/8	.7455	3.9761	5/8	9.471	21.6475
3/32	.00043	.027612	3/16	.8768	4.4301	11/16	10.164	22.6906
1/8	.00102	.049087	1/4	1.0227	4.9087	3/4	10.889	23.7583
5/32	.00200	.076699	5/16	1.1838	5.4119	13/16	11.649	24.8505
3/16	.00345	.110447	3/8	1.3612	5.9396	7/8	12.443	25.9672
7/32	.00548	.150330	7/16	1.5553	6.4918	15/16	13.271	27.1085
1/4	.00818	.196349	1/2	1.7671	7.0686	3	14.137	28.2743
9/32	.01165	.248505	9/16	1.9974	7.6699	1/16	15.039	29.4647
5/16	.01598	.306796	5/8	2.2468	8.2958	1/8	15.979	30.6796
11/32	.02127	.371223	11/16	2.5161	8.9462	3/16	16.957	31.9191
3/8	.02761	.441786	3/4	2.8062	9.6211	1/4	17.974	33.1830
13/32	.03511	.518485	13/16	3.1177	10.3206	5/16	19.031	34.4716
7/16	.04385	.601321	7/8	3.4515	11.0447	3/8	20.129	35.7847
15/32	.05393	.690291	15/16	3.8082	11.7932	7/16	21.268	37.1223
1/2	.0655	.78540	2	4.1888	12.5664	1/2	22.449	38.4845
9/16	.0932	.99402	1/16	4.5939	13.3640	9/16	23.674	39.8712
5/8	.1278	1.22718	1/8	5.0243	14.1862	5/8	24.942	41.2825
11/16	.1701	1.48489	3/16	5.4808	15.0330	11/16	26.254	42.7183
3/4	.2209	1.76714	1/4	5.9641	15.9043	3/4	27.612	44.1786
13/16	.2809	2.07394	5/16	6.4751	16.8001	13/16	29.015	45.6635
7/8	.3508	2.40528	3/8	7.0144	17.7205	7/8	30.466	47.1729
15/16	.4314	2.76116	7/16	7.5828	18.6655	15/16	31.964	48.7069
1	.5236	3.14159	1/2	8.1812	19.6349			

DIAMETERS BY FEET AND INCHES

Diameter Ft.	In.	Volume Cu. Ft.	Area Sq. Ft.	Diameter Ft.	In.	Volume Cu. Ft.	Area Sq. Ft.	Diameter Ft.	In.	Volume Cu. Ft.	Area Sq. Ft.
4	0	33.510	50.2654	11	6	796.33	415.475	18	9	3451.5	1104.47
	3	40.194	56.7450		9	849.40	433.736	19	0	3591.4	1134.11
	6	47.713	63.6172	12	0	904.78	452.389		3	3735.0	1164.16
	9	56.115	70.8821		3	962.51	471.435		6	3882.4	1194.59
5	0	65.450	78.5398		6	1022.6	490.873		9	4033.7	1225.42
	3	75.766	86.5901		9	1085.3	510.705	20	0	4188.8	1256.64
	6	87.114	95.0331	13	0	1150.3	530.929		1	4241.5	1267.13
	9	99.541	103.869		3	1218.0	551.545		2	4294.3	1277.69
6	0	113.10	113.097		6	1288.3	572.555		3	4347.8	1288.25
	3	127.83	122.718		9	1361.2	593.957		4	4401.8	1298.87
	6	143.79	132.732	14	0	1436.8	615.752		5	4455.9	1309.54
	9	161.03	143.139		3	1515.1	637.939		6	4510.9	1320.25
7	0	179.59	153.938		6	1596.3	660.519		7	4566.2	1331.01
	3	199.53	165.130		9	1680.3	683.492		8	4621.8	1341.81
	6	220.89	176.714	15	0	1767.1	706.858		9	4677.9	1352.65
	9	243.73	188.692		3	1857.0	730.616		10	4734.5	1363.54
8	0	268.08	201.062		6	1949.8	754.767		11	4791.4	1374.47
	3	294.01	213.825		9	2045.7	779.311	21	0	4849.0	1385.44
	6	321.56	226.980	16	0	2144.7	804.247		1	4907.0	1396.46
	9	350.77	240.528		3	2246.8	829.576		2	4965.3	1407.52
9	0	381.70	254.469		6	2352.1	855.298		3	5024.3	1418.62
	3	414.40	268.802		9	2460.6	881.412		4	5083.7	1429.77
	6	448.92	283.529	17	0	2572.4	907.920		5	5143.3	1440.97
	9	485.30	298.647		3	2687.6	934.819		6	5203.7	1452.20
10	0	523.60	314.159		6	2806.2	962.112		7	5264.5	1463.48
	3	563.86	330.063		9	2928.2	987.797		8	5325.6	1474.80
	6	606.13	346.360	18	0	3053.6	1017.88		9	5387.4	1486.17
	9	650.46	363.050		3	3182.6	1046.35		10	5449.5	1497.58
11	0	696.91	380.132		6	3315.2	1075.21		11	5512.0	1509.03
	3	745.51	397.608								

TABLE OF SPHERES

Diameter Ft.	In.	Volume Cu. Ft.	Area Sq. Ft.	Diameter Ft.	In.	Volume Cu. Ft.	Area Sq. Ft.	Diameter Ft.	In.	Volume Cu. Ft.	Area Sq. Ft.
22	0	5575.3	1520.53	27	0	10306	2290.22	32	0	17157	3216.99
	1	5638.7	1532.07		1	10402	2304.38		1	17292	3233.77
	2	5703.0	1543.66		2	10498	2318.58		2	17427	3250.59
	3	5767.5	1555.28		3	10595	2332.83		3	17563	3267.45
	4	5832.4	1566.97		4	10692	2347.12		4	17699	3284.36
	5	5898.1	1578.67		5	10790	2361.45		5	17837	3301.31
	6	5964.1	1590.43		6	10889	2375.83		6	17974	3318.30
	7	6030.7	1602.23		7	10989	2383.03		7	18113	3335.35
	8	6097.7	1614.08		8	11089	2404.71		8	18252	3352.43
	9	6165.1	1625.97		9	11189	2419.22		9	18392	3369.55
	10	6233.1	1637.90		10	11290	2433.77		10	18532	3386.72
	11	6301.6	1649.88		11	11391	2448.37		11	18675	3403.94
23	0	6370.6	1661.90	28	0	11494	2463.01	33	0	18817	3421.19
	1	6440.1	1667.93		1	11597	2477.70		1	18960	3438.50
	2	6510.0	1686.08		2	11701	2492.42		2	19103	3455.84
	3	6580.6	1698.23		3	11805	2507.19		3	19247	3473.22
	4	6651.9	1710.42		4	11909	2522.00		4	19393	3490.66
	5	6723.4	1722.66		5	12014	2536.86		5	19538	3508.13
	6	6795.2	1734.94		6	12121	2551.76		6	19685	3525.65
	7	6868.0	1747.27		7	12224	2566.70		7	19832	3543.21
	8	6941.0	1759.64		8	12335	2581.69		8	19980	3560.82
	9	7014.4	1772.05		9	12443	2596.72		9	20129	3578.47
	10	7088.3	1784.51		10	12551	2611.80		10	20278	3596.16
	11	7163.1	1797.01		11	12661	2626.92		11	20428	3613.90
24	0	7238.2	1809.56		0	12760	2642.08	34	0	20580	3631.68
	1	7314.1	1822.15		1	12880	2657.29		1	20731	3649.51
	2	7390.3	1834.78		2	12992	2672.54		2	20883	3667.37
	3	7466.8	1847.45		3	13103	2687.83		3	21037	3685.28
	4	7544.0	1860.17		4	13215	2703.17		4	21191	3703.24
	5	7622.0	1872.93		5	13328	2718.55		5	21346	3721.24
	6	7600.1	1885.74		6	13442	2733.97		6	21501	3739.28
	7	7779.0	1898.59		7	13557	2749.44		7	21658	3757.37
	8	7858.3	1911.48		8	13671	2764.95		8	21814	3775.50
	9	7938.2	1924.42		9	13787	2780.50		9	21972	3792.67
	10	8019.0	1937.40		10	13903	2796.10		10	22131	3811.89
	11	8099.7	1950.43		11	14019	2811.75		11	22335	3830.15
25	0	8181.2	1963.49	30	0	14137	2827.43	35	0	22449	3848.45
	1	8263.6	1976.61		1	14256	2843.16		1	22610	3866.80
	2	8346.2	1989.76		2	14374	2858.94		2	22772	3885.19
	3	8429.1	2002.96		3	14494	2874.75		3	22934	3903.63
	4	8512.8	2016.20		4	14614	2890.62		4	23096	3922.10
	5	8597.2	2029.49		5	14734	2906.52		5	23261	3940.63
	6	8681.2	2042.82		6	14856	2922.46		6	23425	3959.19
	7	8767.6	2056.19		7	14978	2938.46		7	23591	3977.80
	8	8853.4	2069.61		8	15101	2954.49		8	23756	3996.45
	9	8939.8	2083.07		9	15224	2970.57		9	23924	4015.15
	10	9027.0	2096.58		10	15348	2986.69		10	24092	4033.89
	11	9114.6	2110.12		11	15473	3002.86		11	24266	4052.68
26	0	9202.7	2123.71	31	0	15599	3019.07	36	0	24429	4071.50
	1	9291.4	2137.35		1	15725	3035.32		6	25461	4185.38
	2	9381.0	2151.03		2	15852	3051.62	37	0	26522	4300.84
	3	9470.8	2164.75		3	15979	3067.96		6	27612	4417.86
	4	9561.6	2178.52		4	16107	3084.36	38	0	28731	4536.46
	5	9652.5	2192.33		5	16236	3100.77		6	29880	4656.62
	6	9744.0	2206.18		6	16366	3117.24	39	0	31059	4778.36
	7	9836.3	2220.08		7	16496	3133.76		6	32269	4901.67
	8	9929.0	2234.02		8	16627	3150.32	40	0	33510	5026.54
	9	10022	2248.00		9	16758	3166.92		6	34783	5152.99
	10	10116	2262.03		10	16890	3183.57	45	0	47713	6361.72
	11	10210	2276.11		11	17024	3200.26	50	0	65450	7853.98

DECIMAL OF AN INCH AND OF A FOOT

Inch Frac.	Decimal	Foot Frac.	Inch Frac.	Decimal	Foot Frac.	Inch Frac.	Decimal	Foot Frac.	Inch Frac.	Decimal	Foot Frac.
	.0052	1/16		.2552	3 1/16		.5052	6 1/16		.7552	9 1/16
	.0104	1/8		.2604	3 1/8		.5104	6 1/8		.7604	9 1/8
1/64	.015625	3/16	17/64	.265625	3 3/16	33/64	.515625	6 3/16	49/64	.765625	9 3/16
	.0208	1/4		.2708	3 1/4		.5208	6 1/4		.7708	9 1/4
	.0260	5/16		.2760	3 5/16		.5260	6 5/16		.7760	9 5/16
1/32	.03125	3/8	9/32	.28125	3 3/8	17/32	.53125	6 3/8	25/32	.78125	9 3/8
	.0365	7/16		.2865	3 7/16		.5365	6 7/16		.7865	9 7/16
	.0417	1/2		.2917	3 1/2		.5417	6 1/2		.7917	9 1/2
3/64	.046875	9/16	19/64	.296875	3 9/16	35/64	.546875	6 9/16	51/64	.796875	9 9/16
	.0521	5/8		.3021	3 5/8		.5521	6 5/8		.8021	9 5/8
	.0573	11/16		.3073	3 11/16		.5573	6 11/16		.8073	9 11/16
1/16	.0625	3/4	5/16	.3125	3 3/4	9/16	.5625	6 3/4	13/16	.8125	9 3/4
	.0677	13/16		.3177	3 13/16		.5677	6 13/16		.8177	9 13/16
	.0729	7/8		.3229	3 7/8		.5729	6 7/8		.8229	9 7/8
5/64	.078125	15/16	21/64	.328125	3 15/16	37/64	.578125	6 15/16	53/64	.828125	9 15/16
	.0833	1		.3333	4		.5833	7		.8333	10
	.0885	1 1/16		.3385	4 1/16		.5885	7 1/16		.8385	10 1/16
3/32	.09375	1 1/8	11/32	.34375	4 1/8	19/32	.59375	7 1/8	27/32	.84375	10 1/8
	.0990	1 3/16		.3490	4 3/16		.5990	7 3/16		.8490	10 3/16
	.1042	1 1/4		.3542	4 1/4		.6042	7 1/4		.8542	10 1/4
7/64	.109375	1 5/16	23/64	.359375	4 5/16	39/64	.609375	7 5/16	55/64	.859375	10 5/16
	.1146	1 3/8		.3646	4 3/8		.6146	7 3/8		.8646	10 3/8
	.1198	1 7/16		.3698	4 7/16		.6198	7 7/16		.8698	10 7/16
1/8	.1250	1 1/2	3/8	.3750	4 1/2	5/8	.6250	7 1/2	7/8	.8750	10 1/2
	.1302	1 9/16		.3802	4 9/16		.6302	7 9/16		.8802	10 9/16
	.1354	1 5/8		.3854	4 5/8		.6354	7 5/8		.8854	10 5/8
9/64	.140625	1 11/16	25/64	.390625	4 11/16	41/64	.640625	7 11/16	57/64	.890625	10 11/16
	.1458	1 3/4		.3958	4 3/4		.6458	7 3/4		.8958	10 3/4
	.1510	1 13/16		.4010	4 13/16		.6510	7 13/16		.9010	10 13/16
5/32	.15625	1 7/8	13/32	.40625	4 7/8	21/32	.65625	7 7/8	29/32	.90625	10 7/8
	.1615	1 15/16		.4115	4 15/16		.6615	7 15/16		.9115	10 15/16
	.1667	2		.4167	5		.6667	8		.9167	11
11/64	.171875	2 1/16	27/64	.421875	5 1/16	43/64	.671875	8 1/16	59/64	.921875	11 1/16
	.1771	2 1/8		.4271	5 1/8		.6771	8 1/8		.9271	11 1/8
	.1823	2 3/16		.4323	5 3/16		.6823	8 3/16		.9323	11 3/16
3/16	.1875	2 1/4	7/16	.4375	5 1/4	11/16	.6875	8 1/4	15/16	.9375	11 1/4
	.1927	2 5/16		.4427	5 5/16		.6927	8 5/16		.9427	11 5/16
	.1979	2 3/8		.4479	5 3/8		.6979	8 3/8		.9479	11 3/8
13/64	.203125	2 7/16	29/64	.453125	5 7/16	45/64	.703125	8 7/16	61/64	.953125	11 7/16
	.2083	2 1/2		.4583	5 1/2		.7083	8 1/2		.9583	11 1/2
	.2135	2 9/16		.4635	5 9/16		.7135	8 9/16		.9635	11 9/16
7/32	.21875	2 5/8	15/32	.46875	5 5/8	23/32	.71875	8 5/8	31/32	.96875	11 5/8
	.2240	2 11/16		.4740	5 11/16		.7240	8 11/16		.9740	11 11/16
	.2292	2 3/4		.4792	5 3/4		.7292	8 3/4		.9792	11 3/4
15/64	.234375	2 13/16	31/64	.484375	5 13/16	47/64	.734375	8 13/16	63/64	.984375	11 13/16
	.2396	2 7/8		.4896	5 7/8		.7396	8 7/8		.9896	11 7/8
	.2448	2 15/16		.4948	5 15/16		.7448	8 15/16		.9948	11 15/16
1/4	.2500	3	1/2	.5000	6	3/4	.7500	9	1	1.0000	12